TO ASSESS THE DIAGNOSTIC ACCURACY OF CT IN DIFFERENTIATING THE VARYING ETIOLOGIES CAUSING DIFFUSE DISEASE OF THE PERITONEUM WITH HISTOPATHOLOGY CO-RELATION

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF TAMIL NADU DR. M. G. R MEDICAL UNIVERSITY FOR THE DEGREE OF M.D. RADIODIAGNOSIS EXAMINATION TO BE HELD IN MAY 2019.

CERTIFICATE

This is to certify that the dissertation entitled "**To assess the diagnostic accuracy of CT in differentiating the varying aetiologies causing diffuse disease of the peritoneum with histopathology co-relation"** is a bonafide original work done by Dr. Shyjumon George during his academic term – April 2017 to March 2019, at the Christian Medical College, Vellore towards the M.D. Radiodiagnosis Degree Examination of Tamil Nadu Dr. M.G.R MEDICAL UNIVERSITY, Chennai to be held in May 2019.

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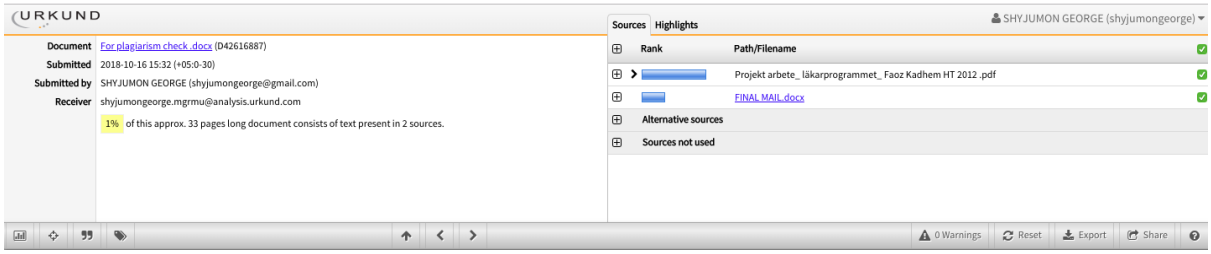
ANTI PLAGIARISM CERTIFICATE



This is to certify that this dissertation work titled "**To assess the diagnostic accuracy of CT in differentiating the varying aetiologies causing diffuse disease of the peritoneum with histopathology co-relation"** of candidate Dr. Shyjumon George, with registration number 201718055 for the award of M.D branch VIII Radiodiagnosis. I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows only 1 percentage of plagiarism in the dissertation.

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To assess the diagnostic accuracy of CT in differentiating varying etiologies causing diffuse disease of the peritoneum
Dr. Shyjumon George, Employment Number: 21100, PG Registrar , Radiology , Dr. Anu Eapen Employment Number: 30125, Radiology, Dr. Kirthi Sathyakumar, Employment Number: 29031, Radiology, Dr. Mandeep Singh Bindra , Employment Number: 32773, Pathology.

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I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Biju George, Addl. Vice Principal (Research), so that the grant money can be released.

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Dr. Biju George
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Dear Dr. Shyjumon George,

The Institutional Review Board **(Blue,** Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "To assess the diagnostic accuracy of CT in differentiating varying etiologies causing diffuse disease of the peritoneum" on January 10th 2018.

The Committee reviewed the following documents:

1. IRB application format
2. Signature Pages
3. Cvs of Drs. Anu, Kirthi, Mandeep, Shyju .
4. No. of documents 1- 3.

The following Institutional Review Board (Blue, Research & Ethics Committee) members were present at the meeting held on January 10th 2018 in the BRTC Conference Hall, Biostatistics Building, Christian Medical College, Vellore 632 004.

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Dr. Ajith Sivadasan	MD, DM	Professor, Neurological Sciences, CMC, Vellore	Internal, Clinician

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of Withdrawals for the study entitled: "To assess the diagnostic accuracy of CT in differentiating varying etiologies causing diffuse disease of the peritoneum" on a monthly basis. Please send copies of this to the Research Office(research@cmcvellore.ac.in).

Fluid Grant Allocation:

A sum of 11,000/- INR (Rupees Eleven Thousand Only) will be granted for 24 months.

Yours sincerely,

Dr. Biju George
Secretary (Ethics Committee)
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Lastly, my wife Dr. Sarin Varghese, my daughter Ezria, my parents and my in-laws for all their prayers, patience and love.

ABSTRACT

Introduction:

The peritoneal cavity is frequently involved in a variety of diseases, both benign and malignant. Cross-sectional imaging plays an important role to diagnose and to assess the extent of peritoneal disease; however, there is considerable overlap in CT findings of the different disease conditions presenting with peritoneal spread. We included and evaluated such patients who presented with peritoneal spread of disease.

Objectives:

- To assess the diagnostic accuracy of CT in differentiating the various etiologies of diffuse peritoneal disease
- To estimate the spectrum and identify the differentiating features of varying etiologies of diffuse peritoneal disease

Methods:

All patients with peritoneal disease who had abdominal CT and subsequently underwent omental biopsies (both surgical and ultrasound guided) from 1st January 2016 to 31st December 2017, were included in our study. The imaging findings were reviewed in PACS by 2 radiologists independently, who were blinded to the patient demographics, the clinical findings and the histopathologic results. The CT findings were assessed under various specific headings to describe peritoneal, mesenteric or omental involvement and few general features like ascites, lymphadenopathy and splenomegaly. The CT findings were then compared and evaluated with histopathology as the gold standard.

Results:

We found that higher age, increasing omental thickness, omental caking, larger mesenteric/peritoneal nodules, visceral scalloping, free ascites, serosal involvement and bilaterality of pleural effusion were associated with malignant etiology while mesenteric thickening/stranding, mesenteric adenopathy, necrotic lymph nodes, splenomegaly and higher attenuation (>20HU) of ascitic fluid were more associated with benign etiology.

Overall, CT had a high diagnostic accuracy for differentiating benign and malignant etiologies of diffuse peritoneal disease with good sensitivity and specificity with substantial interobserver agreement.

Keywords: Omental biopsy, diffuse peritoneal disease, CT findings, histopathology.

Table of Contents

INTRODUCTION

The peritoneum, a complex serosal membrane lining the abdominal cavity and covering the visceral organs encloses a potential space called the peritoneal cavity. This cavity is frequently involved in a variety of benign and malignant processes. These include TB, lymphoma, primary malignancies, metastases from various other primaries like ovaries, GI tract etc. While secondary involvement of the peritoneum is more common, together with primary tumors it often becomes a diagnostic challenge (1). Cross-sectional imaging plays an important role to diagnose and to assess the extent of peritoneal disease; however, there is considerable overlap in CT findings of the different disease conditions presenting with peritoneal spread. We included and evaluated such patients who presented with peritoneal spread of disease.

Our study included patients who had undergone contrast enhanced abdomino-pelvic CT scan in our department and subsequently underwent omental biopsies, both surgical and ultrasound guided. Blinded to the patient demographics, the clinical findings and the histopathologic results the imaging findings were reviewed by 2 radiologists independently. The CT findings were assessed under various specific headings which were predominantly used to describe peritoneal, omental and mesenteric involvement like thickening, stranding, nodularity etc. and also general features like ascites, lymphadenopathy and splenomegaly. The histopathology reports were assessed and the variables on CT were evaluated with histopathology as the gold standard.

AIMS AND OBJECTIVES

AIMS: To assess the role of CT in evaluating diffuse peritoneal disease

OBJECTIVES:

Primary:

- To assess the diagnostic accuracy of CT in differentiating the various etiologies of diffuse peritoneal disease with histopathology co-relation

Secondary:

- To estimate the spectrum of diseases causing diffuse peritoneal disease in a tertiary care centre
- To describe the various manifestations of diseases that cause peritoneal disease
- To identify differentiating features among these that would aid in identifying etiology

REVIEW OF LITERATURE

Introduction

Even though the peritoneum can be affected by both malignant and benign disease processes, there may be considerable overlap in the imaging appearances of peritoneal involvement in these two vastly distinct disease processes with contrasting prognosis. A thorough knowledge of the peritoneal anatomy is thus crucial in understanding the numerous pathologic processes involved.

Anatomy

The peritoneum is a translucent, thin and the largest complex serosal membrane in the body which lines the abdominal cavity, forms the mesenteries and covers the abdomino-pelvic viscera partially or completely. The peritoneum lining the abdominal wall is the parietal and the peritoneum covering a viscus or an organ is called the visceral peritoneum. The peritoneum is composed of a single layer of simple cuboidal epithelium called the mesothelium. The potential space between the parietal and the visceral peritoneum is called the peritoneal cavity. The peritoneal surfaces are lubricated by a thin film of serous fluid, approximately 50 –100 mL which separates the parietal and visceral layers of peritoneum. In men, the peritoneal cavity is closed, whereas it communicates with the extra-peritoneum exteriorly through the fallopian tubes, uterus and the vagina in women (2).

Adequate knowledge of the embryology of the peritoneal development is primary to comprehend its structure and function. First, the primitive gut occupies the peritoneal cavity and is supported by a dorsal and ventral mesentery dividing the peritoneal cavity

into a right and left compartment. Along and within the dorsal and the ventral mesenteries occurs the development of viscera.

Liver develops in the ventral mesentery and within the dorsal mesentery develops the spleen and the pancreas. With continued growth, rotation, folding and reflection the dorsal and ventral mesentery form the different ligaments, omentum and mesenteries to finally form the compartmentalized adult peritoneal space.

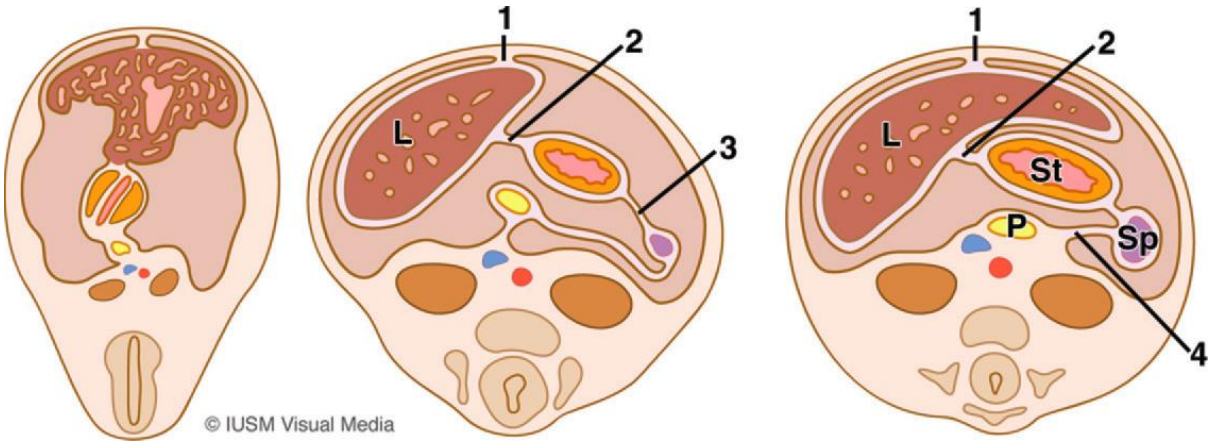


Figure 1: The embryologic development of the dorsal and ventral mesentery at 4th (left), 5th (center), and 6th (right) weeks of gestation, wherein the ventral part of the ventral mesentery becomes the [1] falciform ligament, the dorsal part of the ventral mesentery becomes the [2] lesser omentum, the ventral part of the dorsal mesentery becomes the [3] gastrosplenic ligament and the dorsal part of the dorsal mesentery becomes the [4] splenorenal ligament (2).

Double layers or folds of peritoneum form the peritoneal ligaments that support an organ within the peritoneal cavity and which pass from one organ to another or from an organ to one of the abdominal walls. The ventral and the dorsal mesentery gives rise to most of the abdominal ligaments.

The omentum is a double layer of peritoneum that attaches the stomach and the duodenal bulb to another viscus. The lesser omentum is the fold of peritoneum that attaches the lesser curvature of the stomach and the duodenal bulb to the porta hepatis of the liver superiorly and is formed by the gastrohepatic and hepatoduodenal ligaments.

The gastrohepatic ligament contains the left gastric artery and the coronary vein while the hepatoduodenal ligament contains the hepatic artery, the common hepatic ducts, the portal vein and part of the cystic duct.

The greater omentum hangs from the greater curvature of the stomach akin to an apron and is the largest peritoneal fold, consisting of a double sheet folded upon itself, thus, made up of four layers. From the greater curvature of the stomach and proximal duodenum the two layers of peritoneum descend anterior to the small bowel for an inconsistent distance and then turns superiorly so as to insert into the anterosuperior aspect of the transverse colon. The left border is continuous with the gastro-splenic ligament and the right extends until the origin of the duodenum.

The gastro-splenic ligament is formed by the ventral part of the dorsal mesentery which extends from the greater curvature of the stomach to the splenic hilum. It contains the short gastric vessels and forms a site for collateral circulation during portal vein or splenic vein thrombosis.

The dorsal most aspect of the dorsal mesentery forms the spleno-renal ligament, contains the pancreatic tail and in patients with portal hypertension, collateral circulation may develop within this ligament.

The triangular and the falciform ligaments are formed by the fusion of peritoneal reflections and form the suspensory ligaments of liver. The superior and the inferior coronary ligament reflections fuse to form the triangular ligaments. The left triangular ligament is short and does not compartmentalize the left sub-phrenic space while on the other hand the right triangular ligament is long and compartmentalizes the right sub-

phrenic and sub-hepatic spaces. The bare area of the liver is outlined by the triangular ligaments.

The falciform ligament, a remnant of the ventral mesentery is a thin and broad peritoneal ligament. It contains the paraumbilical veins, the round ligament and the obliterated umbilical vein. It divides the left and right sub-phrenic compartments incompletely and may allow passage of fluid from one side to the other.

The mesentery is a double layer of peritoneum that encloses the intestines and connects them to the posterior abdominal wall. The mesenteric contains lymph nodes, blood vessels, nerves and fat. Mesentery includes the mesoappendix, small bowel mesentery, the transverse mesocolon and the sigmoid mesocolon.

A wide fold of peritoneum connecting the transverse colon to the posterior abdominal wall forms the transverse mesocolon. It is a derivative of dorsal mesentery and contains:

- transverse colon (in the free margin)
- middle colic vessels and their branches
- autonomic nerve fibers
- lymphatics and lymph nodes
- extraperitoneal fatty tissue

Pancreatic head tumors with metastases to the transverse mesocolon are rendered unresectable owing to many small vessels that make vascular control difficult.

The small bowel mesentery, extending from the ligament of Treitz to the ileocecal valve is a broad, fan shaped fold of peritoneum that attaches the jejunum and the ileum to the posterior abdominal wall. It courses from left to right, passing anterior to the horizontal

part of the duodenum, the abdominal aorta, the inferior vena cava, the right ureter and the right psoas muscle successively. The intestinal border is thrown into a number of characteristic pleats or frills. It contains the jejunal and ileal branches of the superior mesenteric arteries and their accompanying veins, nerves and lymphatics.

The peritoneal fold attaching the sigmoid to the posterior pelvic wall forms the sigmoid mesocolon and contains the sigmoidal and the superior rectal vessels. The fold of peritoneum attached to the lower end of small bowel mesentery covering the vermiform appendix and at times suspending the cecum forms the mesoappendix containing the appendiceal vessels.

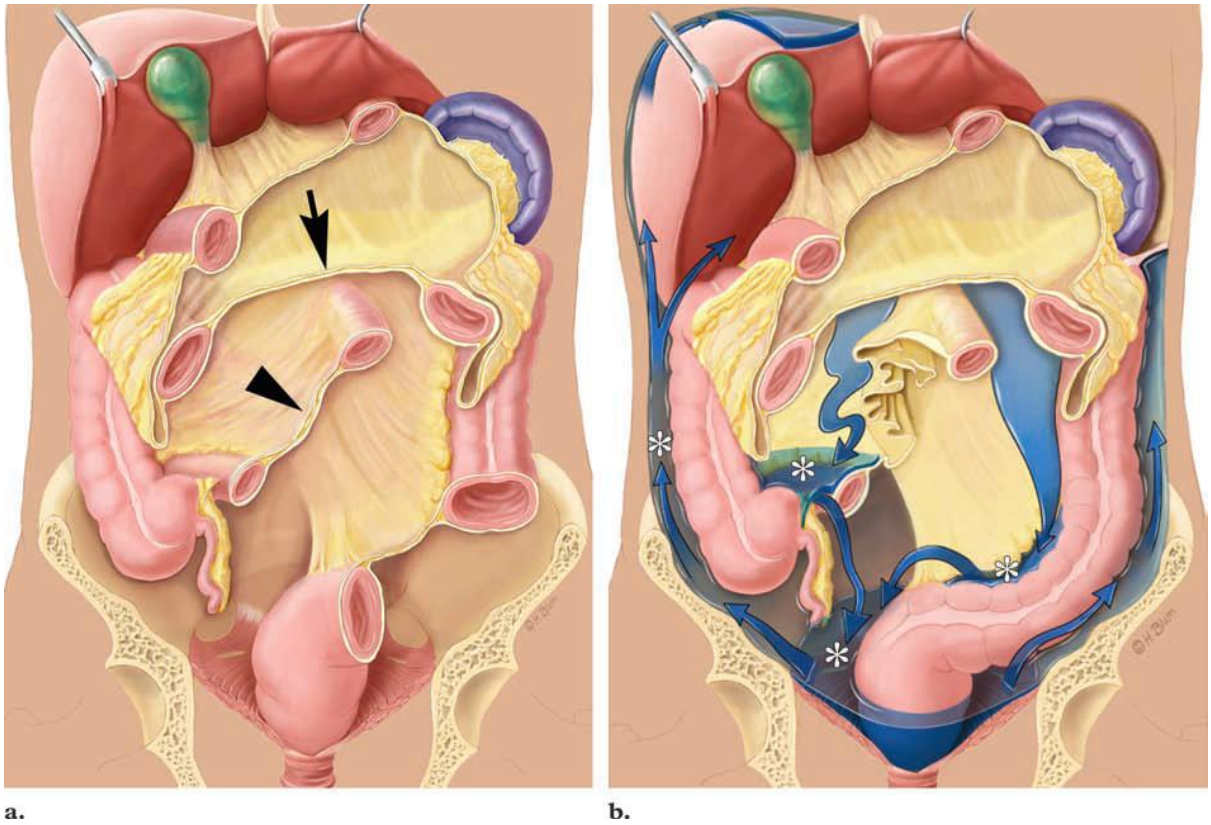


Figure 2: Posterior peritoneal reflections forming the intra-abdominal spaces (1).
(a) Cut surface of the transverse mesocolon (arrow), dividing the peritoneum into supramesocolic and inframesocolic compartments. The root of the small bowel mesentery (arrowhead) is dividing the inframesocolic compartment into the right and the left infracolic spaces. Also shown is the cut surface of the sigmoid mesentery
(b) Pathways of intraperitoneal fluid flow with the four predominant stasis sites (*) of ascitic fluid in the lower abdomen.

The various peritoneal ligaments and their attachments divide the peritoneal cavity into distinct and separate compartments. The transverse mesocolon divides the peritoneum into two major compartments known as the supra-mesocolic and the inframesocolic spaces. The supra-mesocolic space is further divided into the right and the left supramesocolic spaces by the falciform ligament. Similarly, the small bowel mesentery divides the infra-mesocolic space into the right and left infra-mesocolic space. The right supramesocolic spaces include the hepatorenal space, right subphrenic space and the lesser sac, also known as the omental bursa. The lesser sac is further divided into a superior and an inferior recess by the peritoneal reflection of the left gastric artery.

The right infra-mesocolic space is limited by the small bowel mesentery attachment to the cecum and is thus smaller compared to the left inframesocolic space which communicates with the pelvis. Located lateral to the peritoneal reflections of the left and right sides of the colon and communicating freely with the pelvic spaces are the paracolic spaces. The phrenico-colic ligament partially limits the connection between the left subphrenic space and the left paracolic gutter. The larger right paracolic gutter in contrast communicates freely with the right subphrenic space.

The rectovesical space is the most gravity-dependent space for accumulation of fluid in males and in females it is the rectouterine space. The pelvic spaces are divided into lateral and medial compartments by the medial umbilical folds containing the obliterated umbilical arteries. The lateral pelvic compartment on each side is further divided by the inferior epigastric artery into lateral and medial inguinal fossae (2,3).

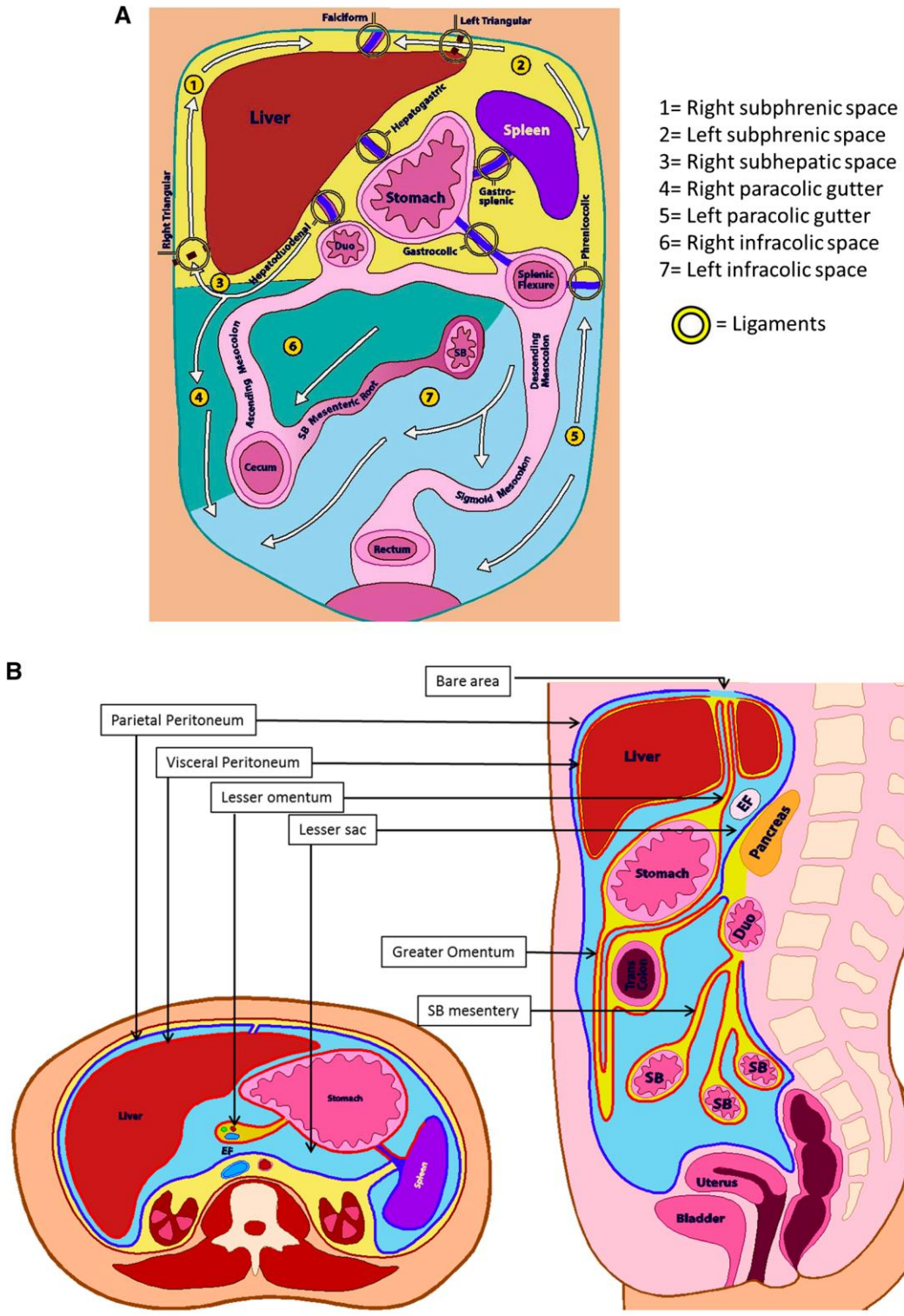


Figure 3: The peritoneal anatomy and the peritoneal spaces with the direction of flow (arrows) of peritoneal fluid (4).

Pathophysiology

A variety of benign and malignant processes frequently involves the peritoneum. The flow of fluid within the peritoneal compartments formed by mesenteric attachments directs the distribution and location of the secondary disease processes. Secondary involvement of peritoneum in the form of tumors and tumor like lesions form a distinct group of pathologic disorders. Although they imitate primary peritoneal tumors, the secondary involvement of peritoneum is more common than primary lesions (1). This often presents a diagnostic challenge. In the present age, cross-sectional imaging plays a central role in the diagnosis and evaluation of the extent of the disease (4). The initial imaging modality is most often the abdomino-pelvic CT which enables identification of peritoneal disease. The accurate description of the severity of the disease and radiologist's exact localization of entire affected sites provide important direction to clinicians in management of the disease (5). Even though CT plays a vital role in the detection of peritoneal tumors and its mimics, owing to the overlap of imaging findings the exact diagnosis and characterization of lesions is often challenging (6). Nevertheless, based on thorough assessment of computed tomography features and fitting clinical context a number of differential diagnoses become easier to distinguish. Marin D et al in their study on a cohort of 18 patients with known or suspected peritoneal carcinomatosis, found extremely high sensitivity (89%) of CT in detecting lesions 0.5 cm or more in diameter. Lesions less than 0.5 cm showed a markedly lower sensitivity (43%). A low false positive (9%) rate was noted in the detection of peritoneal metastases, probably owing to the relatively low number of peritoneal malignancy mimics that are of benign etiology. The solitary noteworthy exception was that the

mesentery accounted for 4 of the 10 false-positive findings, with 43% of relative specificity of CT. They postulated that this may be linked to the variety of pathologic conditions which can affect the mesentery, including inflammatory, vascular and malignant disorders with subsequent manifestation of almost indistinguishable findings on CT. Their study demonstrated that use of 64-section MDCT with the aid of isotropic reformatted sagittal and coronal images was found to be extremely effective technique in the detection of peritoneal metastases, especially in areas like the hemi-diaphragms, the mesentery, the dome of the liver and the pelvis which are sub-optimally assessed on axial imaging alone with sensitivity, specificity, positive and negative predictive values of 75%, 92%, 90% and 79% respectively (7). Thus, to assess areas that are difficult to evaluate on axial images as well as to confirm the presence of metastatic peritoneal implants, multiplanar imaging shows immense potential (8).

Although not a comprehensive list, malignant peritoneal mesothelioma, peritoneal lymphomatosis, peritoneal TB and pseudomyxoma peritonei are the chief disorders that imitate peritoneal carcinomatosis (9). The most common diffuse disease of the peritoneum is peritoneal carcinomatosis which primarily is defined as disseminated intraperitoneal tumor of origin other than peritoneum itself. A clear understanding of the dissemination routes of peritoneal carcinomatosis and the flow dynamics of peritoneal circulation is of utmost importance to recognize the signs of peritoneal carcinomatosis. The spread is mainly by the following four routes:

1) Hematogenous
2) Contiguous spread
3) Lymphatic

4) Peritoneal surface spread by gravity and peristalsis

Peritoneal carcinomatosis

Peritoneal carcinomatosis can be either focal or diffuse. On sonography, ascitic fluid associated with peritoneal carcinomatosis may contain hypoechoic particulate matter reflecting proteinaceous exudate. Peritoneal nodules are generally hypoechoic or sheet like. Ascites is a common finding, formed as a result of obstruction of the sub-phrenic lymphatic vessels as well as increased capillary permeability causing excessive production of peritoneal fluid. Omental infiltration is usually in the form of echogenic plaques which are seen attached to the abdominal wall or floating in ascites. There may be replacement of omental fat with fibrosis and tumor leading to the characteristic appearance of "omental caking." New onset ascites, location of the ascitic fluid and a peritoneum which is thickened, shows nodularity and enhances should raise the suspicion of a malignant process. Mesentery of the small bowel may get infiltrated forming nodules, causing stiffening, straightening and increase in density of mesenteric vasculature giving a stellate appearance on CT which is very characteristic. A common complication of peritoneal carcinomatosis is small bowel obstruction owing to infiltration by tumor (1,9).

Malignant mesothelioma

Malignant mesothelioma, an aggressive neoplasm that arises from the mesothelial cells of the serosal membranes of the body cavities including the peritoneum, pleura, pericardium or the tunica vaginalis of testis with peritoneum accounting for about 10-15%. The pathological subtypes of peritoneal mesothelioma include the well

differentiated papillary mesothelioma, cystic mesothelioma and malignant mesothelioma. History of heavy and prolonged asbestos exposure is seen in more than half the population affected with malignant mesothelioma, and predominantly includes older men, during the fifth and sixth decades. Thoracic CT examination should be performed if and when calcified peritoneal plaques are observed, to look for signs of asbestos exposure which include calcified pleural plaques and thickening of the pleura. Peritoneal involvement in malignant mesothelioma can be either diffuse or localized mass like. The wet form of the disease which presents with abdominal discomfort and distention involves diffuse sheet like peritoneal thickening, nodularity, omental masses and ascites, which is usually moderate in amount. The dry form, which usually presents with abdominal pain is associated with localized peritoneal based masses with none or minimal ascites. The tumor infiltrates rapidly within the peritoneal cavity with rare nodal and distant metastatic spread, accounting for an expected median survival of only 10 months at the time of diagnosis. The cystic mesothelioma subtype of peritoneal mesothelioma is rare and has no association with asbestos exposure. Usually seen in young to middle aged women with a characteristic involvement of the pelvis, this subtype is known to be associated with pelvic inflammatory disease or past history of abdominal surgery. Imaging features depend on the gross morphology which include grape like multilocular cystic, unilocular cystic or multiple unilocular cystic masses. Although cystic mesothelioma is considered benign, malignant transformation has been documented. The well-differentiated papillary mesothelioma is a rare indolent subtype and predominantly occurs in women in the reproductive age. Similar to the cystic mesothelioma, this subtype is not associated with asbestos exposure either and

generally behaves in a benign fashion. On imaging, the findings are quite non-specific and usually include thickening of the peritoneum, nodularity, infiltration of the omentum and, ascites (10,11).

Lymphoma

In lymphoma, the peritoneum could be involved either primarily or as a secondary process. Primary peritoneal lymphomas, also known as body cavity-based lymphomas are rare and usually found in immunocompromised patients, particularly those infected with HIV. Even though the lymphoma remains limited to the originating cavity in most patients, these have a poor prognosis as they are aggressive and high grade. The secondary involvement of peritoneum does not have any predilection for immunocompromised state and can occur in general population as well. Secondary lymphomatosis involves ascites, diffuse thickening, enhancement and nodularity of the peritoneum, along with caking and infiltration of omentum and small bowel mesentery Although these findings are also seen in peritoneal carcinomatosis, the presence of splenomegaly and lymphadenopathy (especially retrocrural or mesenteric) may instead point towards lymphomatosis. On the other hand, primary effusion lymphoma manifests most commonly as malignant ascites with no associated lymph nodal enlargement or discrete lesions (1,4).

Peritoneal tuberculosis

The most common presentation of abdominal tuberculosis affecting the abdomen is in the form of peritoneal tuberculosis and involves the peritoneal cavity, omentum and the mesentery. The route of spread is mostly haematogenous, other routes proposed being

rupture of infected lymph nodes, direct extension from gastrointestinal dissemination and not infrequently from infection of the genitourinary tract. Peritoneal TB is typically divided grossly into dry, wet and the fibrous types. There is considerable overlap of features among the three types with smooth peritoneal thickening being a consistent feature. The commonest type is the wet type (90%) and usually manifests as ascites which may be loculated or free with diffuse and smooth thickening of the peritoneum. The ascitic fluid is usually of high attenuation owing to high cellular and protein content. The finding of ascites with fat-fluid level is found to be highly specific for tuberculous ascites (12). The second common type (7%) is the fibrous type which predominantly involves thickening of the omentum, fixing of the bowel loops with loculated ascites. The least common type is the dry type (3%) which involves thickened peritoneum and mesentery, caseous nodules, lymphadenopathy with peritoneal and fibrinous adhesions. Lymphadenopathy is most often associated with necrosis and calcification. In upto 80% of patients, the omentum may be altered and shows diffuse infiltration, nodularity and caking which is less frequent (< 20%) compared to peritoneal carcinomatosis (40%). Another common finding is the involvement of mesentery which may be mild in the form of striations, engorgement of mesenteric vessels, densification of fat to a more widespread and pronounced infiltration and nodularity of the mesenteric leaves. The varied range of clinical appearances along with and overlapping imaging findings still make the diagnosis of peritoneal tuberculosis an arduous challenge (3,12).

Pseudomyxoma peritonei

Pseudomyxoma peritonei, also known as jelly beans is a clinical / radiologic descriptive entity which describes the finding of copious amount of thick, gelatinous or mucinous material covering the peritoneal cavity surfaces and mucinous ascites. It is a rare condition, more common in women than men and with a mean age of 49 years at diagnosis. Common clinical presentation is progressive pain in the abdomen, with abdominal distension and loss of weight. Often, when pseudomyxoma peritonei is present predominantly in the right lower quadrant, patients present with a clinical picture similar to those of appendicitis. Pathologically, pseudomyxoma has been divided into pseudomyxoma peritonei and peritoneal mucinous carcinomatosis. The former variety contains benign or cells from well-differentiated (low-grade) mucinous carcinomas. It tends to spread along the peritoneal surfaces without invading the stroma and is thus amenable to surgical debulking and has a better prognosis. The latter on the other hand has a larger fibrotic component which may be adherent to all peritoneal surfaces. Pathologically, it is characterized by high grade, invasive mucinous carcinoma which is moderate or poorly differentiated and originates from mucinous carcinoma of the gastrointestinal tract, pancreas, gallbladder or the ovary. On plain abdominal radiography, increased opacification of the entire abdomen with poorly defined intraabdominal organs and obliterated psoas margins may be seen. There may be obscuration of the inferior hepatic margin or medial displacement of tip of the liver due to focal mucin collections in the sub-hepatic space. Mucin in the para-colic gutters may displace the ascending and the descending colons centrally. Symmetrical areas of opacity are seen on either side of the bladder when mucin is present in the para-vesical

spaces. Calcifications may be seen within pseudomyxoma and are usually faint, amorphous or curvilinear. Echogenic septations with non-mobile echoes may be seen on sonography in the ascitic fluid owing to the gelatinous nature of pseudomyxoma peritonei. On CT, multiple focal low attenuation areas causing scalloping but without any direct infiltration of the intraperitoneal upper abdominal organs, typically the liver and the spleen may be seen. Parietal peritoneal and omental involvement may be seen in the form of echogenic sheet like masses. The intestines are echogenic and centrally displaced surrounded by hypoechoic gelatinous fluid giving a starburst appearance. Infiltration of the abdominal viscera with omental caking, mesenteric or retroperitoneal lymph node enlargement and pleural effusion or masses should raise the possibility of mucinous carcinomatosis as diagnosis. Furthermore, the volume of mucin is comparatively lesser in mucinous peritoneal carcinomatosis. Careful inspection of the appendix and ovaries should be done in all newly diagnosed cases to rule out a primary (1,4).

Peritoneal sarcomatosis

Peritoneal sarcomatosis, a rare peritoneal surface malignancy is the intraperitoneal spread of sarcoma. These arise from either recurrence of intraabdominal sarcomas or as metastases from extremity sarcomas. Common tumors giving rise to peritoneal sarcomatosis are gastrointestinal stromal tumors (GISTs), leiomyosarcomas, and liposarcomas. The features of peritoneal sarcomatosis are quite similar to that of peritoneal carcinomatosis. However, unlike carcinomatosis, the implants in the peritoneum from sarcomas are more often deforming, spherical, mostly vascular, and is usually associated with minimal ascites. The incidence of hydronephrosis and bowel

obstruction is lesser in sarcomatosis. GIST is the most common sarcoma associated with peritoneal sarcomatosis. On imaging these are mostly seen as large, heterogeneously enhancing necrotic masses with minimal or no ascites. The most common retroperitoneal sarcoma is the liposarcoma. Most subtypes are well differentiated and dedifferentiated with decrease in the macroscopic fat corresponding to increase in aggressiveness of histological subtypes(13,14). Peritoneal spread is mostly seen with the myxoid subtype and are seen as low density homogenous masses. The peritoneal masses in retroperitoneal liposarcoma are heterogenous with variable amounts of fat and soft tissue, often with mild to moderate enhancement of the soft tissue component and occasional calcification. Primary peritoneal involvement by leiomyosarcoma, a malignancy of smooth muscle origin occurs rarely and may be seen as diffuse thickening of the peritoneum or as focal discrete masses. The peritoneal implants are similar to the ones in liposarcoma and in addition are larger and intensely enhancing. Hemoperitoneum or bowel obstruction are the associated complications. Ascites is not a common finding in either of these conditions (15).

Splenosis and leiomyomatosis

Dissemination of splenic tissue within the peritoneal cavity causes a condition known as splenosis. It is usually associated with trauma or surgery causing disruption of the splenic capsule. Along with peritoneal cavity, splenosis can also be seen along the diaphragmatic surface within the thoracic cavity as single or multiple well-defined lobulated or round soft tissue masses with attenuation similar to the native spleen. In indeterminate cases, nuclear imaging could be used to demonstrate splenic tissue (4,16).

Disseminated peritoneal leiomyomatosis is an extremely rare benign disorder characterized by multiple leiomyomas in the peritoneum. It is an incidental finding in women in the reproductive age group, associated with elevated reproductive hormones and is primarily located in the grater omentum and the pelvic peritoneum and less commonly involves the superior areas of the peritoneum. On CT these are seen as multiple peritoneal nodules which are diffusely spread and often with a soft tissue pelvic mass with lobules which causes displacement of the pelvic organs. There is no associated enlargement of lymph nodes. On MRI, these masses have signal intensity similar to skeletal and smooth muscles on T1 and T2 with variable contrast enhancement. The diagnosis is usually made by image guided or surgical biopsy. This condition generally has an indolent course, although malignant transformation and recurrence has been reported (9,17).

Endometriosis

Endometriosis, a common condition affecting the peritoneal cavity of women in child bearing age and is characterized by functional endometrial glands and stroma being present outside the uterus. It commonly affects both the visceral and the parietal peritoneum. The mean age at diagnosis is 25-29 years with an incidence of approximately 10% in women of child bearing age. Patients could be completely asymptomatic or may present with infertility, dysmenorrhea, pelvic pain, dyspareunia or dysfunctional uterine bleeding. The symptoms do not necessarily co-relate with the stage of the disease. Pathologically, it is characterized by hemorrhagic, reddish brown cysts or nodules on the peritoneal surfaces. Fibrosis and peritoneal adhesions may be seen if the lesions are long standing. The fibrosis can distort the normal anatomy of the

involved structures, particularly the fallopian tubes, the ovaries, the pouch of Douglas and may even cause bowel obstruction owing to tethering. The ectopic endometrial tissue undergoes the same hormone dependent changes as is seen in the uterine endometrial tissue. On sonography the peritoneal involvement is in the form of non-specific nodules or plaques on the peritoneal surfaces with no significant internal vascularity. These cysts are not known to resolve. On CT, endometriotic masses are non-specific and may be of varying density. MRI has higher specificity for the diagnosis of endometriotic masses and is primarily based on detection of blood products within the lesions. These are seen as T1 hyperintense and T2 hypointense lesions and gives the characteristic T2 shading pattern. Another common pattern is the presence of a low signal intensity rim signifying fibrosis and hemosiderin deposition on both T1 and T2 imaging. MR is less sensitive for detection of plaque like lesions and endometrial implants which are small in size as these shows variable signal intensity. Additional techniques including fat suppressed and chemical shift imaging help in improving the sensitivity of MR in picking up endometriotic lesions (1).

Gliomatosis peritonei

Gliomatosis peritonei is rare condition characterized by the presence of benign, mature glial implants in the peritoneum. It occurs usually in association with solid or immature ovarian teratomas with very rare malignant transformation. On CT, the findings are very similar to peritoneal carcinomatosis and include peritoneal enhancing nodules and masses, omental caking and ascites along with a pelvic or an adnexal mass. These deposits are usually multilobular with homogeneous high signal intensity on T2W MR imaging (1,18).

Peritoneal echinococcosis

Peritoneal echinococcosis is a rare condition caused by the parasite Echinococcus granulosus. It is can either be primary or secondary. Secondary involvement of the peritoneum from a hepatic primary is the most common presentation with the primary type being extremely rare. Spread outside liver or lungs is thought to be via systemic or lymphatic circulation. Majority of the cases are associated with previous surgery for hepatic HC. Asymptomatic micro-ruptures of hepatic cysts into the peritoneal cavity can occur spontaneously, although are rare. Peritoneal seeding may also be seen in post-traumatic rupture of hydatid cyst in the liver. CT and MR are the imaging modalities of choice for assessment. On the basis of appearance, hydatid cysts can be classified into four types, simple cyst with no internal architecture form the type I, type II cysts contain the daughter cyst(s) and matrix, calcified cysts form the type III and type IV cysts are hydatid cysts with complications including rupture and superinfection. On CT, these are seen usually as multiple cysts which can arise anywhere in the peritoneal cavity with characteristic features including daughter cysts, cyst wall thickening, wall calcification, presence of internal septations and hydatid sand. Differentiating the unilocular type 1 hydatid cyst from mesenteric or intestinal duplication cysts is difficult. Involvement of the retroperitoneum does not have any specific feature and can include any type of hydatid cyst (19–21).

Inflammatory pseudotumor

Inflammatory pseudotumor is a rare, benign, chronic inflammatory lesion which has been called by different names, including plasma cell granuloma and inflammatory myofibroblastic tumor. Symptoms secondary to mass effect are usually seen in patients

with intraabdominal lesions. Multiple sites may be involved including the mesentery and peritoneum. It has an indolent course and the systemic signs and symptoms including fever, weight loss, thrombocytosis, anemia and polyclonal hypergammaglobulinemia seen in around one fourth of the patients usually resolve after complete surgical resection. Incomplete surgical resections have been reported to result in local recurrences. Imaging findings are non-specific and may include masses with well-defined or infiltrating margins which reach up to the adjoining bowel segments and into the neighboring mesentery. These are seen as solid mesenteric masses with mixed echotexture and prominent vascularity on ultrasonography and color Doppler imaging. On CT, the enhancement pattern seen is variable with larger lesions showing central necrosis in the form of hypodense areas (1,22,23).

Desmoplastic small round cell tumor

Desmoplastic small round cell tumor (DSRCT) is a rare malignancy seen in adolescents and young adults and has a very poor prognosis. Histologically, the tumor is characterized by the presence of ‘‘small round blue cells’’ as are also seen in Wilm’s tumor, peripheral primitive neuroectodermal tumor, Ewing sarcoma, and Askin tumor. On CT, this is characterized by diffuse peritoneal thickening of the peritoneum, nodularity, masses which may demonstrate tiny calcifications, heterogeneous attenuation and post-contrast enhancement and ascites. On MRI, these show high signal intensity on T2 weighted imaging and are usually low on T1 weighted imaging. Rarely, it may present as a solitary peritoneal mass and the diagnosis should always be considered in young adults with no obvious primary organ of origin (4,24).

A.C. O'Neill et al in their study on a cohort of 122 patients with pathologically proven peritoneal spread, found distinctive patterns of involvement according to the varying etiology. Peritoneal sarcomatosis was associated with discrete well-defined nodules with a smooth outline, carcinomatosis was characterized by thickening of the peritoneum and omental caking, as well as absence of discrete nodules and lymphomatosis although similar to carcinomatosis in many aspects, was associated with splenomegaly, large mesenteric mass and lymphadenopathy. These findings could guide the radiologist in differentiating among these malignant etiologies (25).

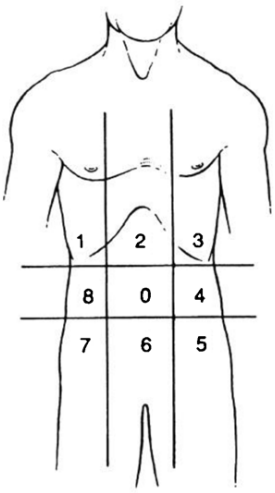
Ha et al in a study in 1996 to determine the potential of CT in distinguishing TB peritonitis from peritoneal carcinomatosis found that although most findings overlapped, combination of certain findings could help in differentiating the two. They found that mesenteric changes including thickening and macro-nodularity (size >5mm) was more seen in peritoneal TB (98%) than in peritoneal carcinomatosis (70%). Omental infiltration was more irregular in peritoneal carcinomatosis patients. Splenomegaly and splenic calcifications were seen more in TB peritonitis patients. Overall, the sensitivity of CT for predicting the diagnosis was found to be 69% for TB peritonitis and 91% for peritoneal carcinomatosis (26).

Charoensak et al in 2012 conducted a similar study to differentiate CT findings between TB peritonitis and peritoneal carcinomatosis on a study population comprising of pathologically proven 27 tuberculous peritonitis and 53 peritoneal carcinomatosis patients. Ascites was the most common finding in tuberculous peritonitis (96.3%), commoner than in peritoneal carcinomatosis and was more often loculated (23.1%). Peritoneal abnormalities in the form of thickening and nodularity were more common

in peritoneal carcinomatosis than in TB peritonitis. Uniform and smooth thickening of the peritoneum was more frequently encountered in TB peritonitis (80%) while peritoneal nodules were more associated with peritoneal carcinomatosis (76.7%). Omental nodularity and caking were found to be more frequent in peritoneal carcinomatosis whereas smudge type was more common in tuberculous peritonitis (87.5%). Mesenteric disease in the form of thickening, nodularity and stellate appearance was more frequently identified in tuberculous peritonitis (88.9%). Lymph nodes with size >10mm were more frequently seen with peritoneal carcinomatosis (84%) than in TB peritonitis which had more lymph nodes with size < 10mm (57.1%) (27).

Peritoneal carcinomatosis and pseudomyxoma peritonei arise from either primary or secondary peritoneal cancer and are treated by cytoreductive surgery which primarily comprises of removal of all macroscopic disease. The suitability for the complete resection is determined by preoperative imaging commonly using a scoring system designed to estimate the extent of peritoneal carcinomatosis called the peritoneal cancer index (PCI).

Peritoneal Cancer Index

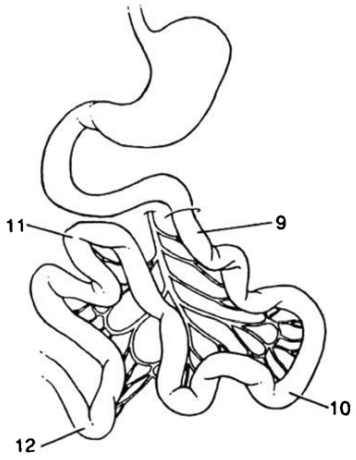


Regions	Lesion Size
0 Central	____
1 Right Upper	____
2 Epigastrium	____
3 Left Upper	____
4 Left Flank	____
5 Left Lower	____
6 Pelvis	____
7 Right Lower	____
8 Right Flank	____
9 Upper Jejunum	____
10 Lower Jejunum	____
11 Upper Ileum	____
12 Lower Ileum	____

PCI ☐

Lesion Size Score

LS 0 No tumor seen
LS 1 Tumor up to 0.5 cm
LS 2 Tumor up to 5.0 cm
LS 3 Tumor > 5.0 cm or confluence



K Flicek et al in 2015 conducted a study to assess the correlation of tumor burden assessment as estimated by the radiologic PCI with actual surgical PCI. They included a total of 42 patients who underwent cytoreductive surgery for either PC or PMP. They used a standardized template to assess different locations in the abdomen and the tumor amount present in those locations to generate a radiologic PCI. The radiologic PCI thus obtained was compared with surgical PCI as the gold standard. The radiologic PCI score had a sensitivity, specificity, positive and a negative predictive value of 76% (22/29), 69% (9/13), 85% (22/26) and 56% (9/16) respectively as compared to surgical PCI. Overall, the radiological and surgical scoring was similar in 31/42 (74%) of patients (28).

D. Diaz-Gil et al conducted a study in 2016 to assess the correlation of PCI obtained by CT with serum levels of tumor marker CA-125 and 5-year survival in advanced stage

ovarian cancer patients. They evaluated CT-PCI of 82 patients with stage III or stage IV ovarian cancer using Sugarbaker classification prior to the cytoreductive surgery. Using linear regression analysis, they found that there was significant co-relation ($r = 0.487$, $P < 0.001$) between the pre-surgical CT-PCI and the pre-surgical CA-125 serum levels. Using multivariate binary logistic regression, significant improvement in 5-year survival was noted with lower CT- PCI and Eastern Cooperative Oncology Group (ECOG) score (29).

A. Dohan et al in 2017 conducted a study to evaluate the added value of MRI in combination with CT as compared to CT alone in patients with peritoneal metastases, evaluating a total of 28 patients. CT-PCI was determined first from the analysis of CT images alone by two observers, MRI examinations in combination with CT was then analyzed by the two observers to determine a second set of PCI values. Using surgical PCI as reference, the sensitivity and negative predictive values of the two imaging sets were then estimated. They found that CT in combination with MRI was more accurate in preoperative estimation of PCI compared with CT alone. The absolute difference in the PCI values compared to the surgical PCI obtained by using CT alone was more than in combination with MRI (mean (s.d.) 4·89(4·73) versus 3·96(4·10); $P = 0·010$). The number of true-positive findings and sensitivity (from 63 to 81 per cent for reader 1; from 44 to 81 per cent for reader 2) increased for both the observers with the added use of MRI examinations. The increase in sensitivity was found to be more for patients with a moderate volume of disease (30).

Employing a multimodality approach with a clear understanding of the clinical and pathophysiology of each disease in co-relation with the patient's history, the radiologist

can improve the diagnostic yield of these diseases (3). We in our current study, plan to assess the diagnostic accuracy of CT in differentiating the etiology of diffuse peritoneal disease with histopathology co-relation and to develop a CT algorithm to aid diagnosis and management.

MATERIALS AND METHODS

TYPE OF STUDY: Retrospective observational study for assessing diagnostic accuracy

Scheme of research:

All patients with peritoneal disease who had contrast enhanced CT imaging and subsequently underwent omental biopsies (both surgical and ultrasound guided) were included in our study. All such patients who had their omental biopsies from 1st January 2016 to 31st December 2017 were included in this study. The imaging findings were reviewed in PACS by 2 radiologists independently, who were blinded to the patient demographics, the clinical findings and the histopathologic results. The CT findings were assessed under various specific headings, predominantly so as to describe peritoneal, mesenteric or omental involvement like thickening, enhancement, nodularity etc. and also general features like ascites, lymphadenopathy and splenomegaly. The histopathology reports were then finally assessed and the variables on CT were evaluated with histopathology as the gold standard.

Sample size calculation:

Our pilot study of three months duration for CT correlation with HPE, showed the following findings:

- 25 out of 34 –had concurrent diagnosis (both CT and HPE)
- 4 out of 34 –had discordant diagnosis
- 5 out of 34 –had equivocal findings (no definite CT diagnosis)

This analysis suggested a sensitivity of ~ 73 %. Previous studies have a shown a sensitivity of 75%.

Overall, considering a sensitivity of 70% for the purpose of sample size calculation

With 10% precision and 95% confidence interval using the following formula:

n = (4*p*q) / (d*d): p-sensitivity=70%, q=1-p, d=10%

A minimum sample of 84 subjects was calculated. We included a total of 136 patients in our study.

Inclusion criteria:

- All patients with peritoneal disease who had CT examinations in our department and subsequently underwent omental biopsies (both surgical and ultrasound guided).

Exclusion criteria:

- Patients with no contrast enhanced CT examination of the abdomen and pelvis
- Inconclusive biopsy results
- Patients with known malignancy / obvious primary malignancy on CT

Index or experimental test: Contrast enhanced CT examination of the abdomen and pelvis was the experimental test (CECT)

Evaluators:

1) First observer: Combined analysis done by a radiologist with 4 years' experience along with another radiologist with 7 years' experience.
2) Second observer: Radiologist with 16 years' experience.

Minimizing bias:

The index test was interpreted independently of the reference standard and without knowledge of the results.

Knowing the histopathological diagnosis prior to or during the assessment of the CT findings is a definite source of bias. The reporting radiologists were blinded to the patient demographics as well as to the clinical findings and the histopathologic results during the image interpretation until the assessment of CT findings of all the recruited patients was completed and were ready for correlation with HPE reports.

Informed Consent:

As the study was a retrospective analysis and did not involve any direct patient interaction (we were blinded to patient demographics and clinical history) and no additional investigations were conducted on the patients, the requirement for an informed consent was waived.

Statistical methods:

Data were summarized using mean(SD)/ median(IQR) for continuous variables and categorical variables were expressed as frequency and percentage. The baseline continuous variables were compared between the benign and malignant using independent-t-test, and the categorical variables were compared using chi-square statistics. The significant predictors at 5% level were chosen and a logistic regression was performed mutually adjusted for the predictors selected. The estimate of effect size was given as Odds ratio with 95% CI. The diagnostic accuracy of radiology with histology results were presented with 95%CI. All the statistical analysis were performed using STATA/ IC 15.0

RESULTS AND ANALYSIS

Total patients evaluated: **136**

Baseline patient characteristics:

1. **Age distribution**

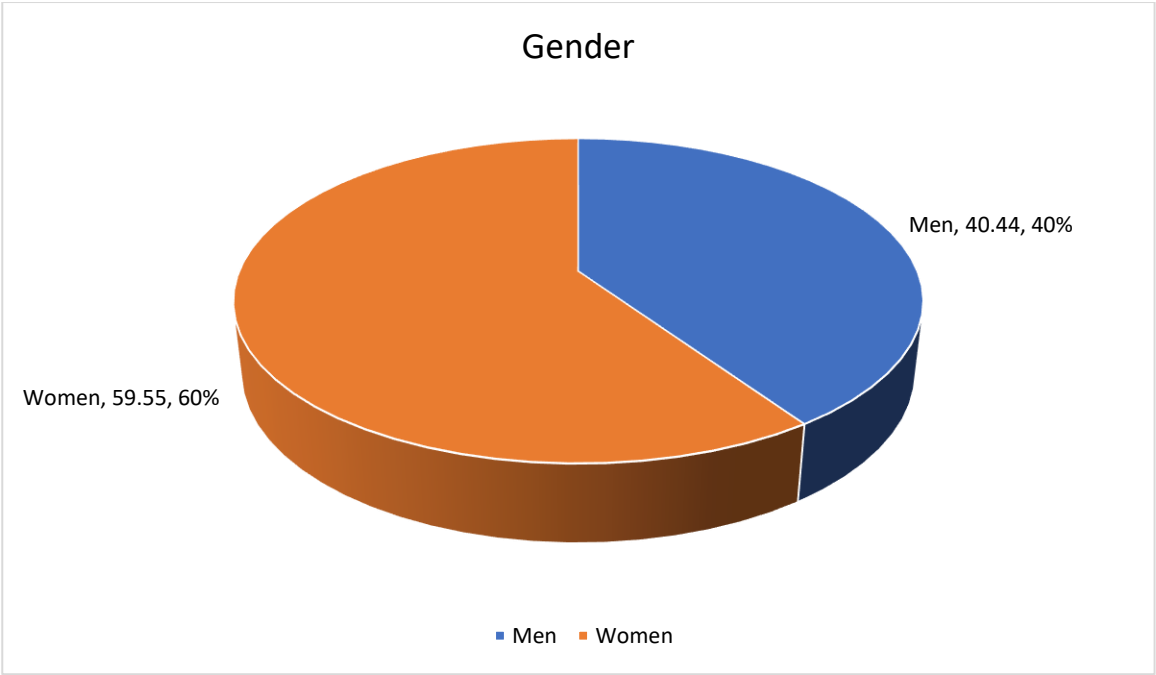
   The mean age of patients included in our study was 44 +/- 16.3 years with an age range of 10 to 88 years.

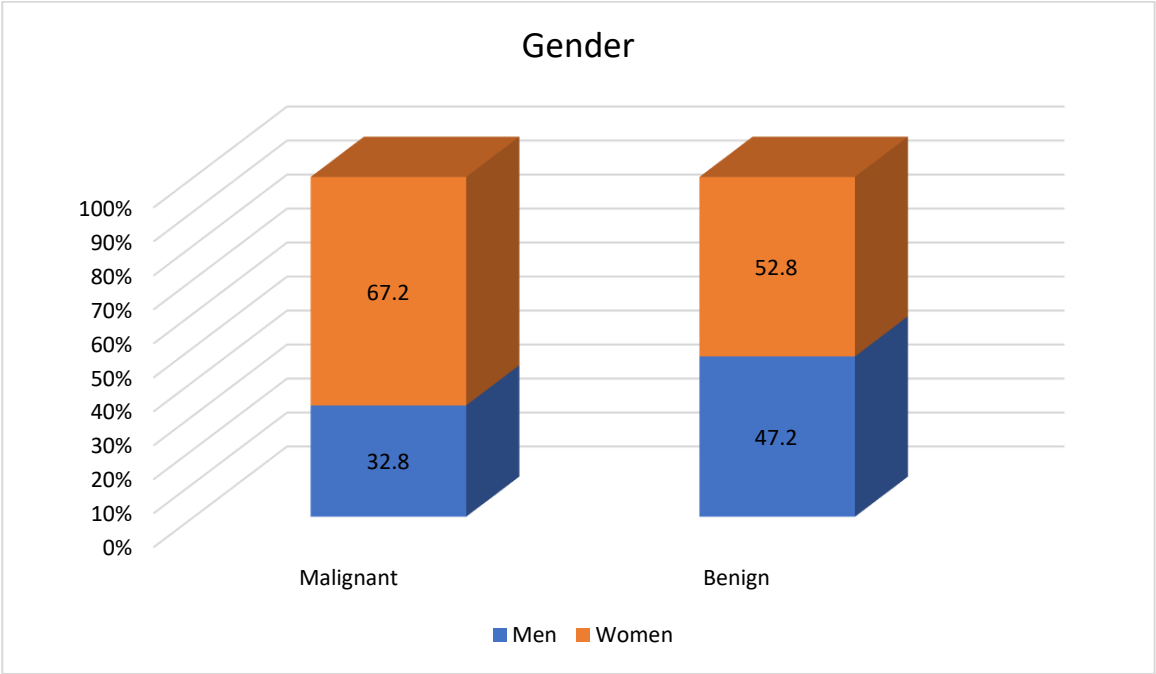
	Benign	Malignant	OR (95% CI)	P- Value
Age	34.9 +/- 14.1	53.75 +/- 12.6	1.10 (1.06,1.14)	<0.001

- Higher age had a statistically significant positive association with malignant etiology with an odds ratio of 1.1 (95%CI,1.06-1.14) and a p-value of <0.001.

2. **Gender distribution**

- 40.4 % (n = 55) of our patients were men while 59.5% (n = 81) were women.
- Among the patients with benign etiology, 47.2 % (n = 34) were men, while 52.8% (n = 38) were women.
- Among the patients with malignant etiology, 32.8% (n = 21) were men, while 67.2% (n = 43) were women.





Sex	Benign	Malignant	OR (95% CI)	P- Value
Male	34 (47.2)	21 (32.8)	0.54 (0.27, 1.09)	0.087
Female	38 (52.8)	43 (67.2)		

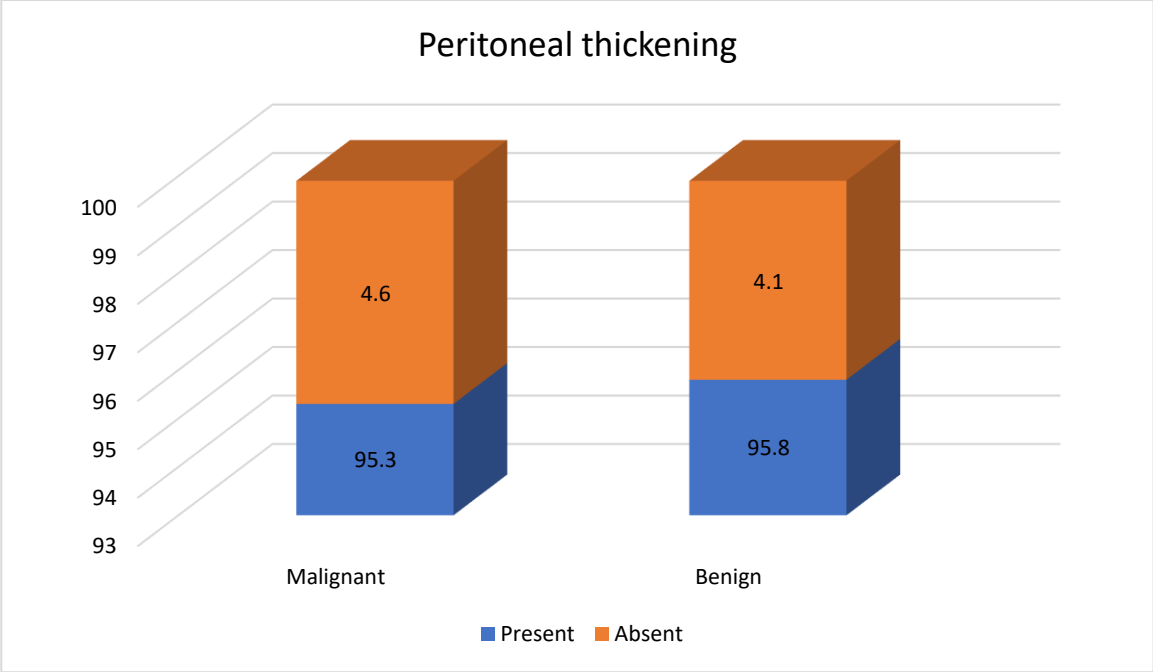
- There was no gender predilection for benign or malignant etiology of the peritoneal disease.

CT findings

a. Peritoneum

Peritoneum was thickened in 95.59 % (130) of the patients.

- Among the 64 patients with malignant etiology, peritoneal thickening was present in 61 patients (95.3%).
- Among the 72 patients with benign etiology, peritoneal thickening was present in 69 patients (95.8%).



Peritoneal thickening	Malignant	Benign	OR (95% CI)	P- Value
Present	61 (95.3)	69 (95.8)	0.88 (0.17, 4.54)	0.882
Absent	3 (4.6)	3 (4.1)		

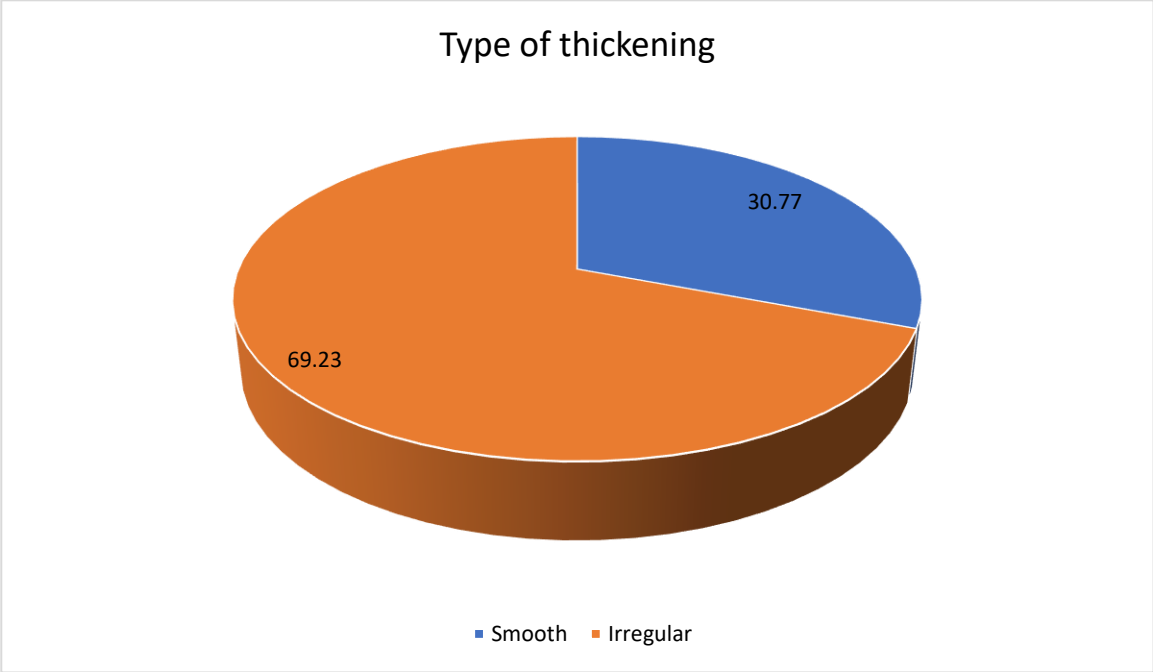
- Presence of peritoneal thickening did not have any bearing on whether the etiology was benign or malignant.

- The mean thickness of peritoneum was 6.78 mm with a minimum of 1 mm and a maximum of 85 mm. The standard deviation was 9.65 mm.

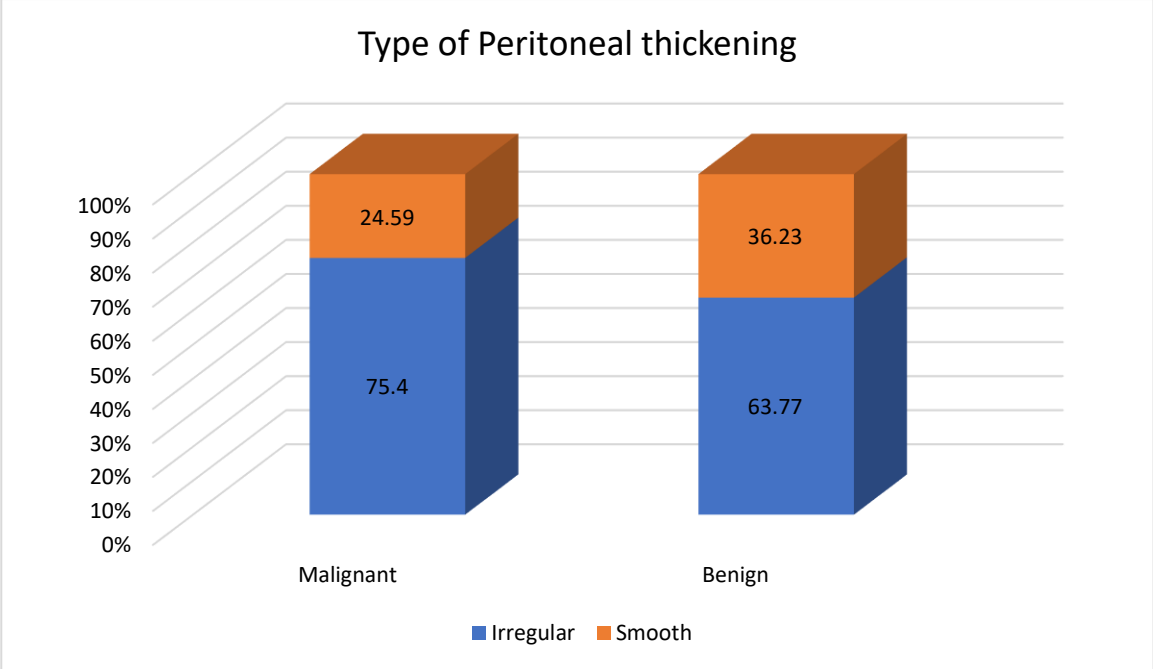
	Benign	Malignant	OR (95% CI)	P- Value
Peritoneal thickness (mm)	5.11 +/- 5.79	8.67 +/- 12.45	**1.06 (0.99,1.14)**	0.071

- The thickness of peritoneum did not contribute to differentiating malignant from benign etiology.

- Peritoneal thickening was irregular in 69.2% (n = 90) of patients and smooth in 30.8 % (n = 40) of the patients.



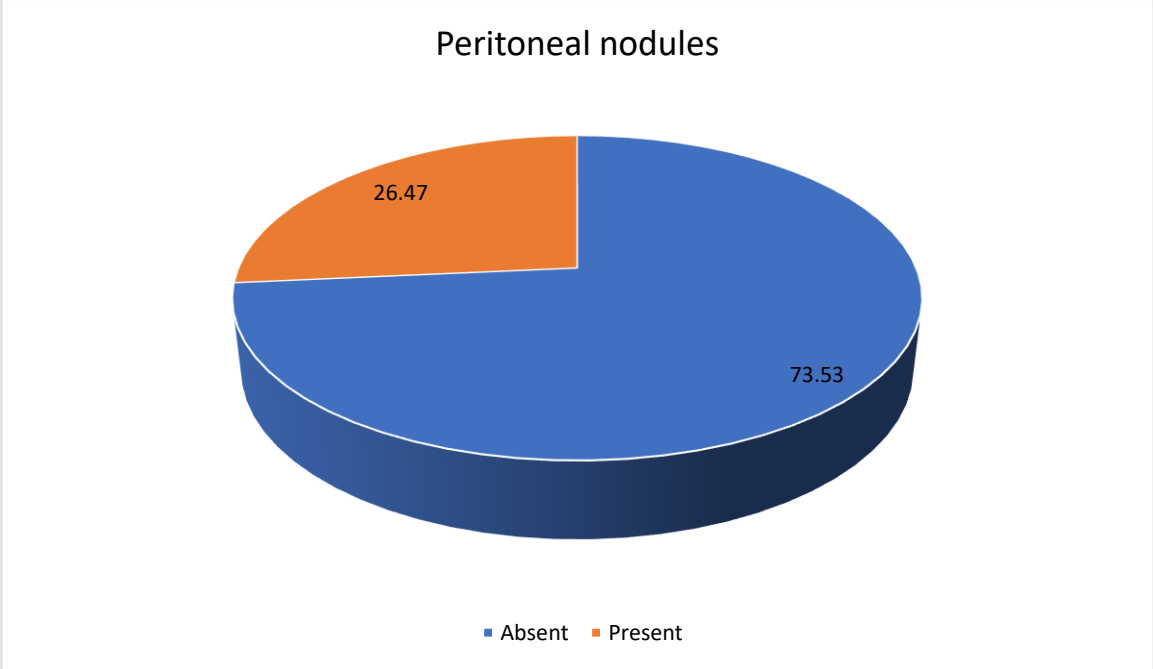
- Among the 61 patients with malignant etiology and peritoneal thickening, the peritoneal thickening was smooth in 24.6% (n = 15) patients and irregular in 75.4% (n = 46) patients.
- Among 69 patients with benign etiology, peritoneal thickening was smooth in 36.2% (n = 25) patients while it was irregular in 63.8% (n = 44) patients.



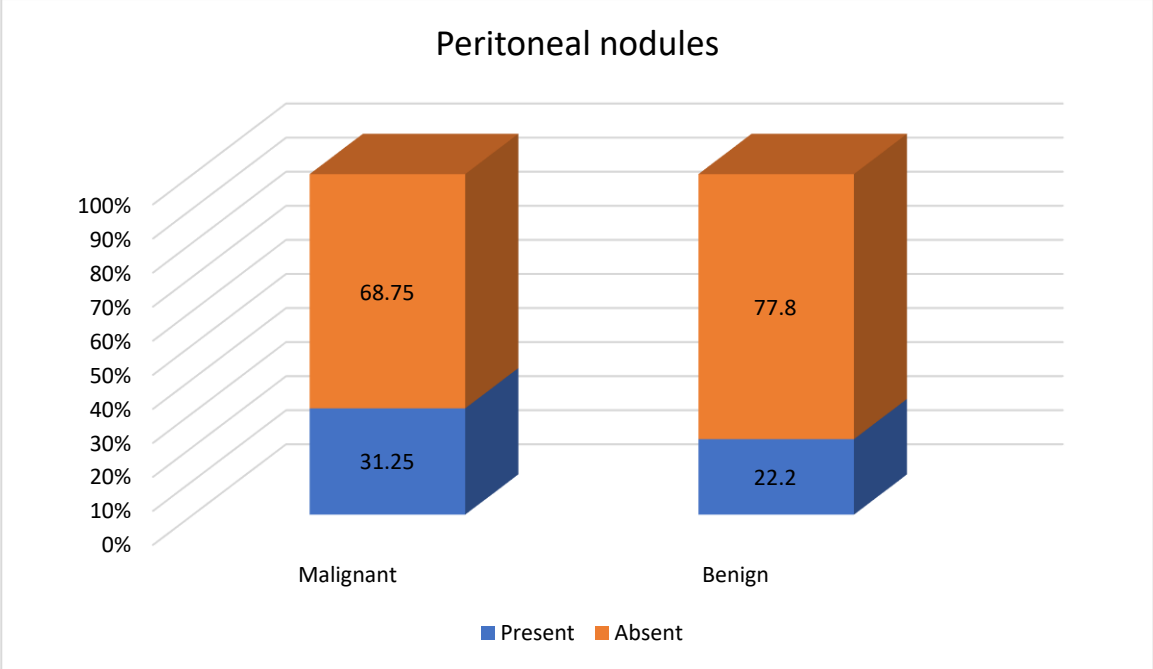
Type of thickening	Malignant	Benign	OR (95% CI)	P- Value
Irregular	46 (75.41)	44 (63.77)	1.74 (0.81, 3.8)	0.151
Smooth	15 (24.59)	25 (36.23)		

- The type of peritoneal thickening, whether it was smooth or irregular did not contribute to differentiating malignant from benign etiology

- Peritoneal nodules were seen in 26.5 % (n = 36) of the patients while 73.5% (n = 100) of the patients did not have peritoneal nodules



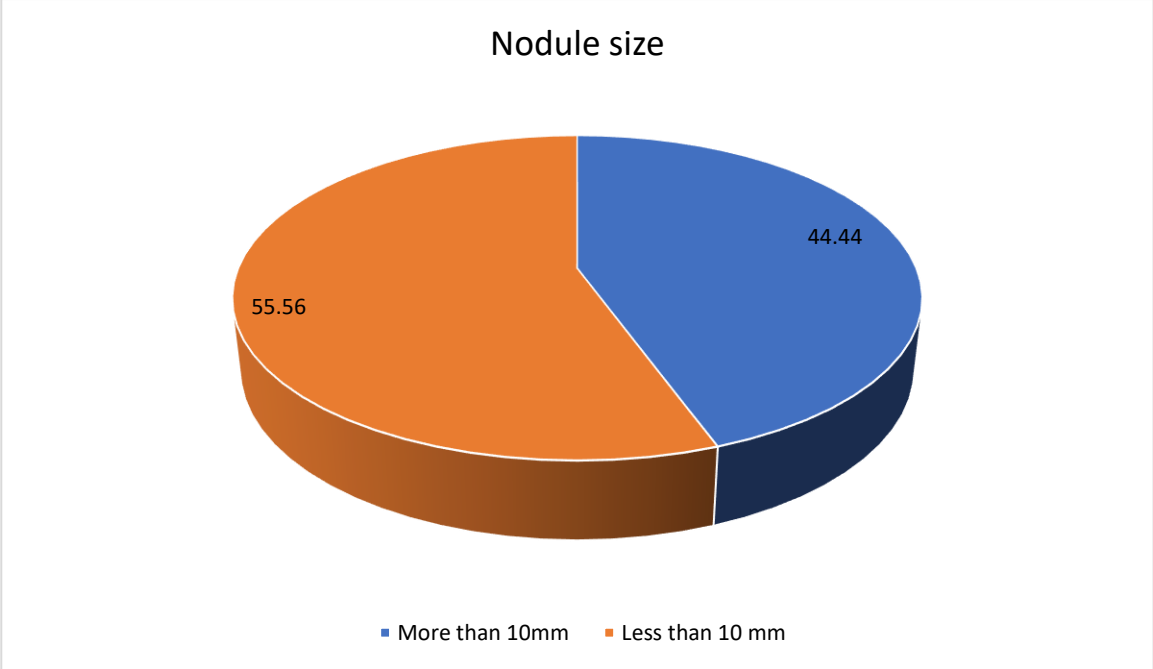
- Of the 64 patients with malignant etiology, peritoneal nodules were present in 31.25% (n = 20) patients while 68.75% (n = 44) patients had no peritoneal nodules.
- Of the 72 patients with benign etiology, peritoneal nodules were present in 22.2% (n = 16) while 77.8% (n = 56) patients had no peritoneal nodules.



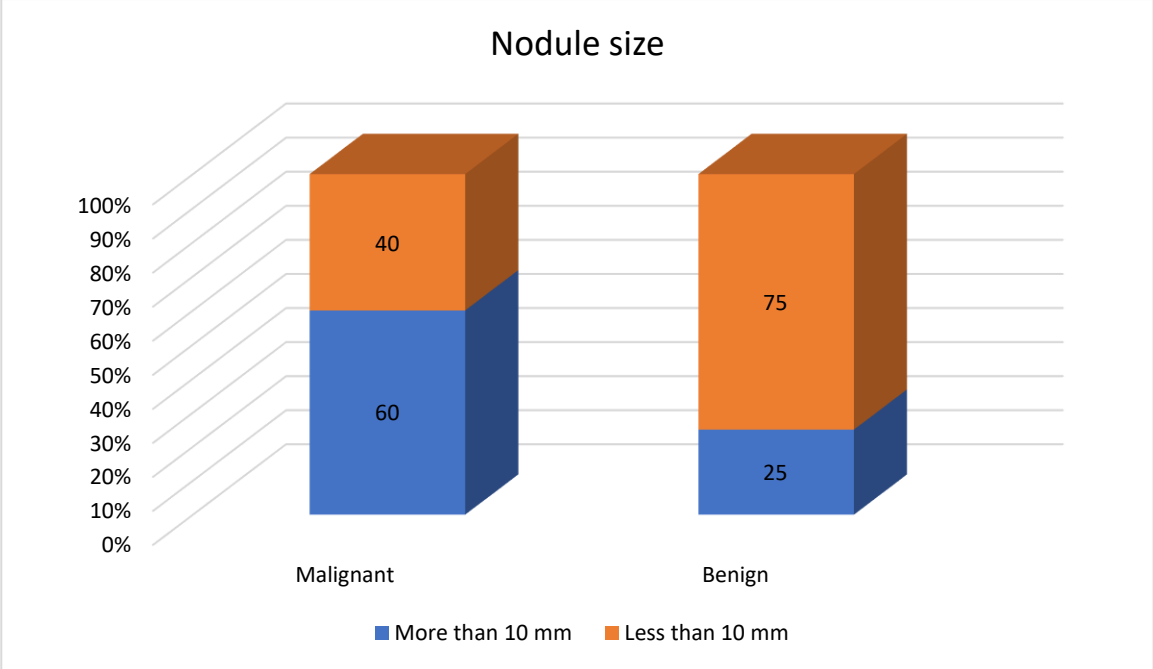
Peritoneal nodules	Malignant	Benign	OR (95% CI)	P- Value
Present	20 (31.25)	16 (22.2)	1.59 (0.73, 3.42)	0.233
Absent	44 (68.75)	56 77.8)		

- The presence of peritoneal nodules did not contribute in differentiating malignant from benign etiology.

- Out of the 36 patients with peritoneal nodules, 55.6% (n = 20) patients had nodules of sizes < 10 mm while 44.4% (n = 16) had nodules of size > 10 mm



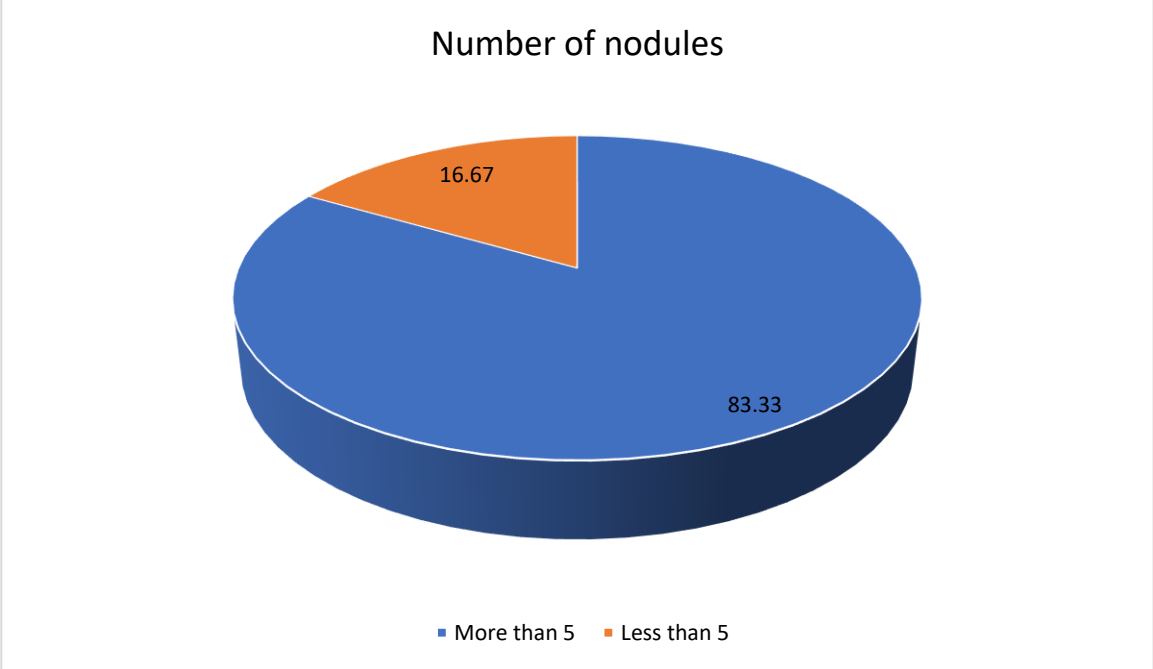
- Among the 20 patients with peritoneal nodules who had malignant etiology, 40% (n = 8) had nodules with sizes less than 10 mm, while 60% (n = 12) had sizes more than 10 mm.
- Among the 16 patients with peritoneal nodules who had benign etiology, 25% (n = 4) had nodules with sizes more than 10 mm while 75% (n = 12) had less than 10 mm.



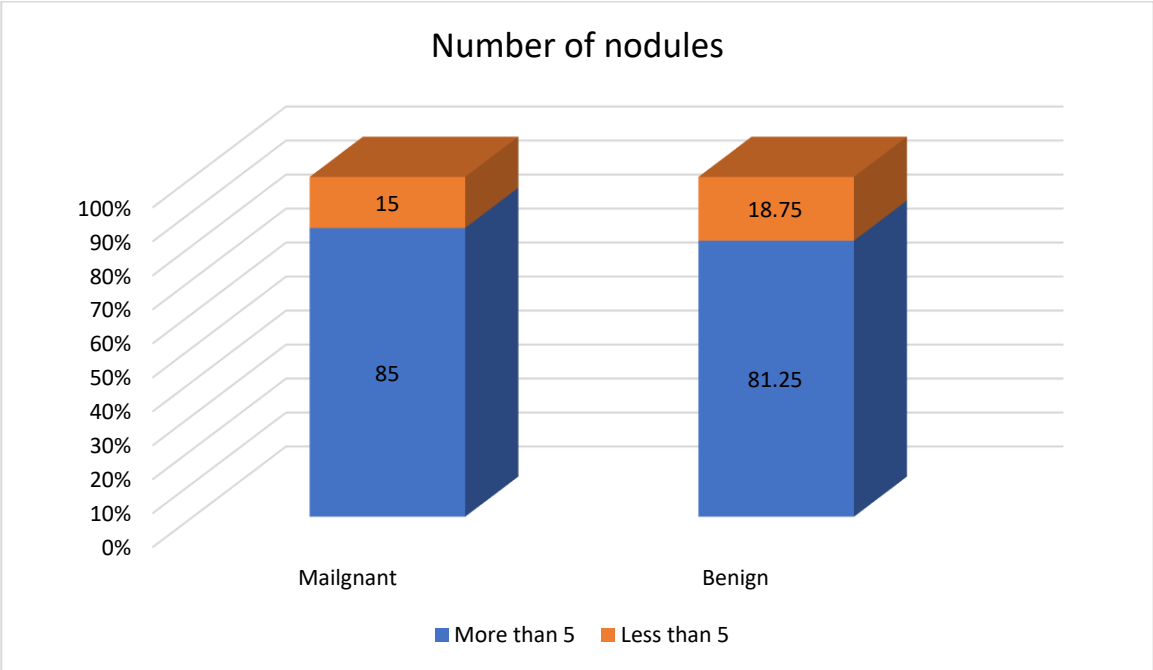
Size of p. nodules	Malignant	Benign	OR (95% CI)	P- Value
>10 mm	12 (60)	4 (25)	4.5 (1.06, 19. 04)	0.035
< 10 mm	8 (40)	12 (75)		

- The size of peritoneal nodules >10 mm had a statistically significant association (p = 0.035) with malignant etiology.

- Of the 36 patients with peritoneal nodules, 16.7% (n = 6) patients had less than 5 nodules, while 83.3% (n = 30) had more than 5 nodules.



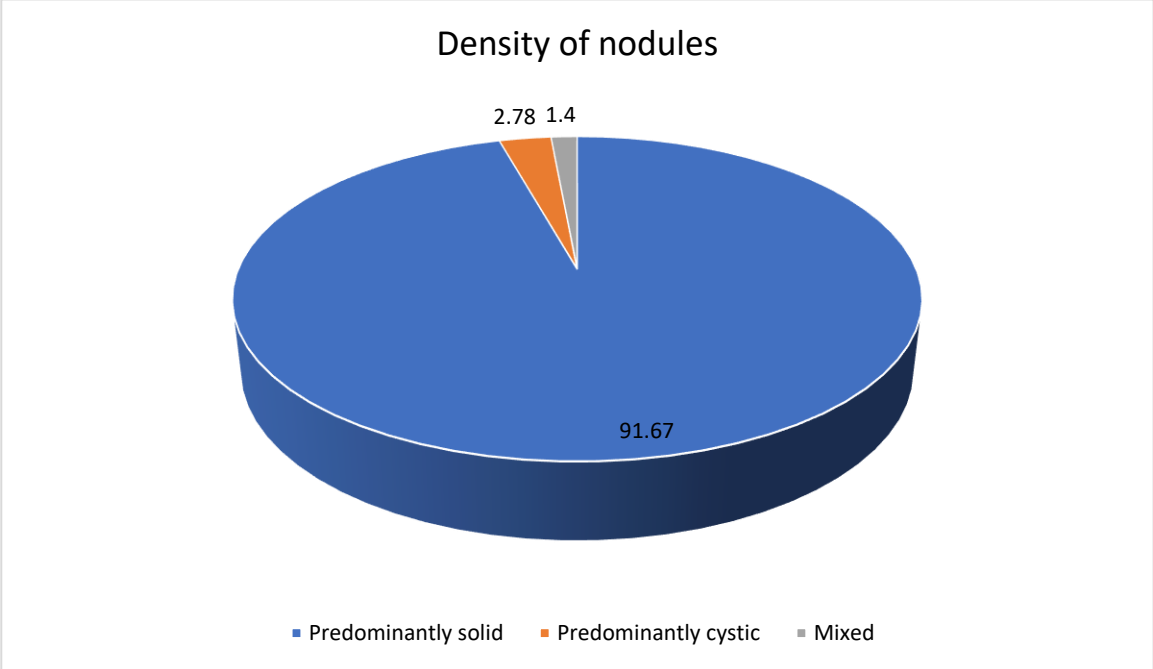
- Among 20 patients with peritoneal nodules who had malignant etiology, 15% (n = 3) had peritoneal nodules less than 5 in number, while 85% (n = 17) had more than 5 peritoneal nodules
- Among the 16 patients with peritoneal nodules who had benign etiology, 81.3% (n = 13) had more than 5 while 18.7% (n = 3) had less than 5.



Number of p. nodules	Malignant	Benign	OR (95% CI)	P- Value
>5	17 (85)	13 (81.25)	1.30 (0.22, 7.56)	0.764
<5	3 (15)	3 (18.75)		

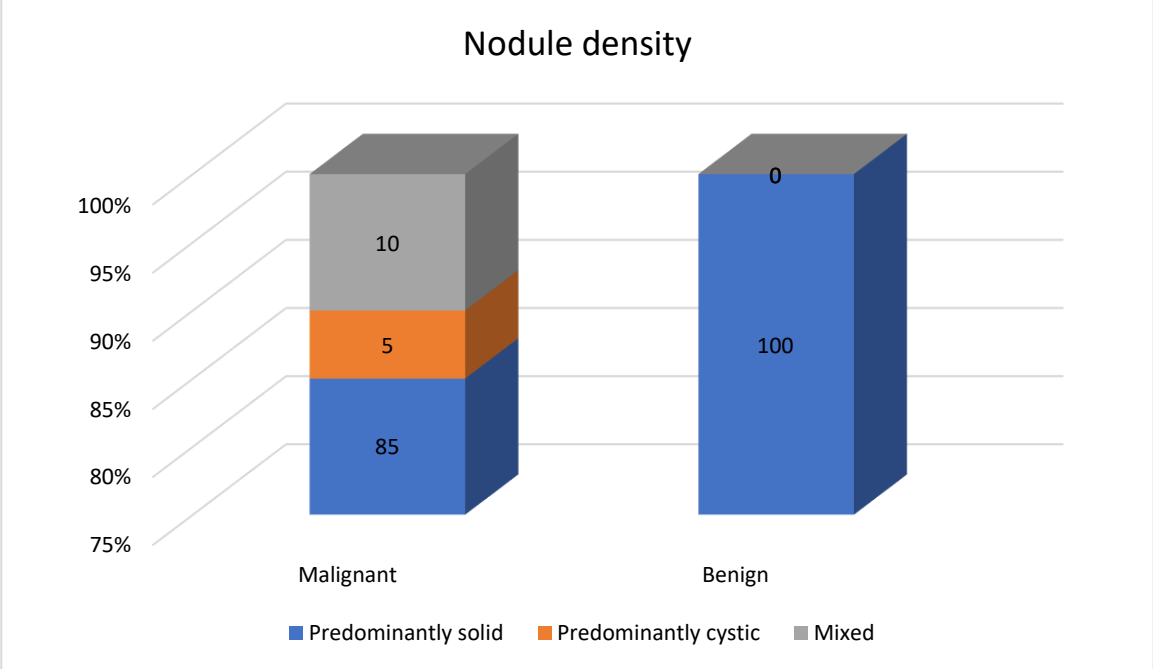
- The number of peritoneal nodules (>5/< 5) was not useful in differentiating malignant from benign etiology of peritoneal disease (p = 0.764).

- Of the 36 patients with peritoneal nodules, 91.7% (n = 33) of the peritoneal nodules were predominantly-solid, 2.8 % (n = 1) was predominantly-cystic while 5.6% (n = 2) were of mixed density.

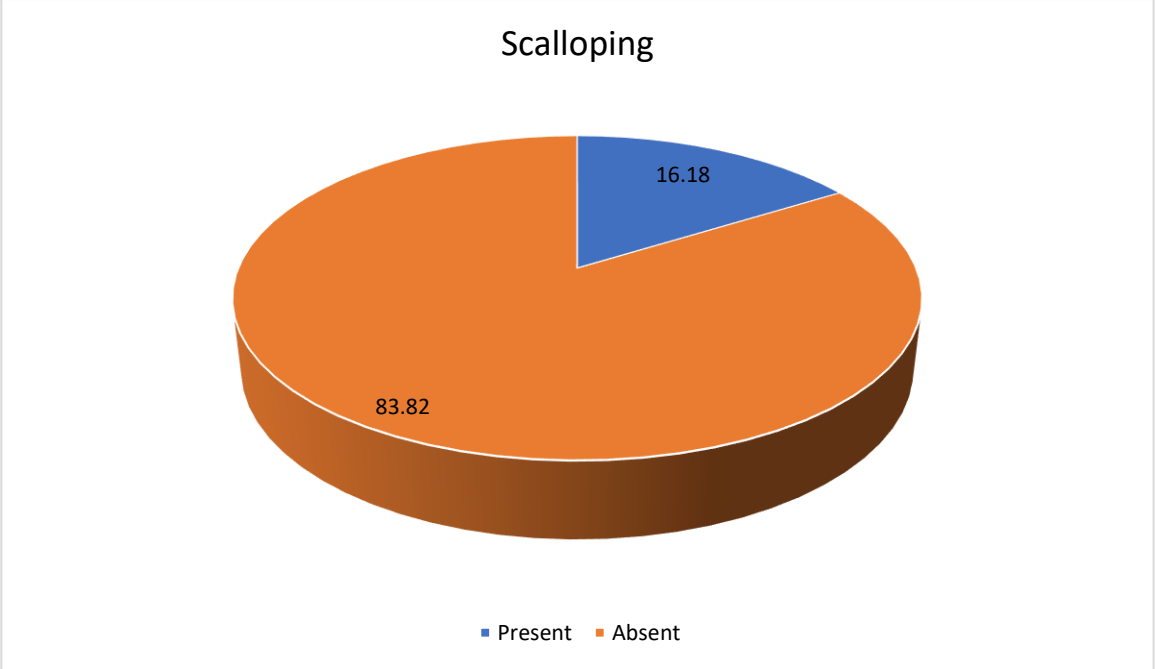


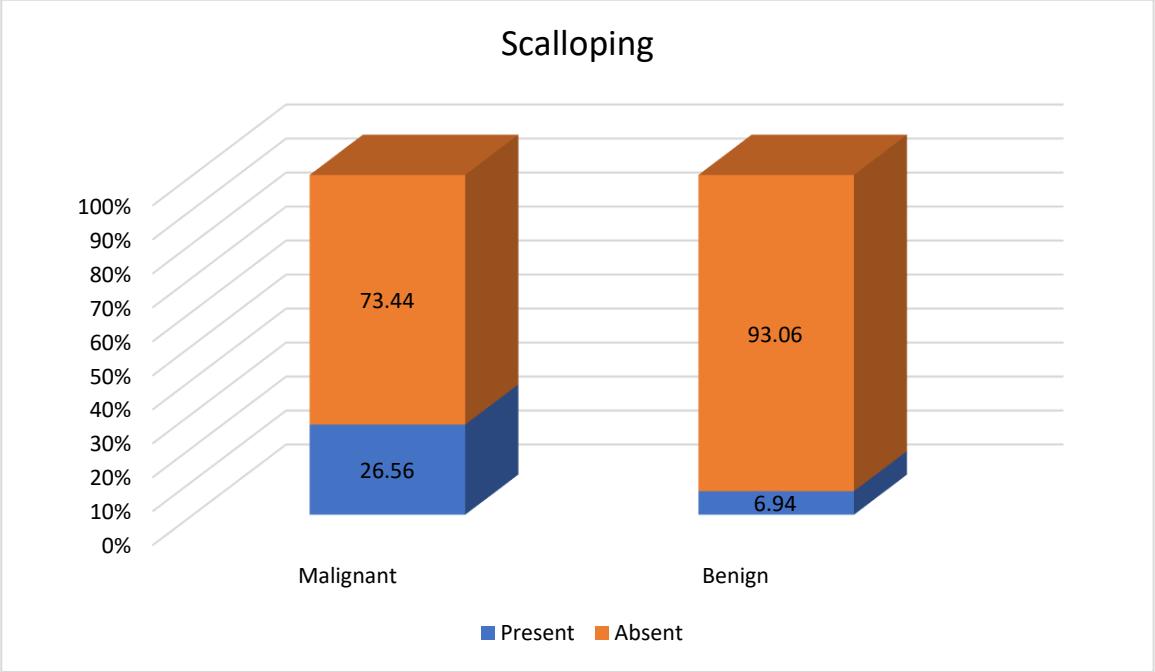
- Among the 20 patients with peritoneal nodules who had malignant etiology, 85% (n = 17) were of predominantly-solid density, 5% (1) of predominantly-cystic density while 10% (n = 2) were of mixed density

- The density of peritoneal nodules in all the 16 patients who had benign etiology was predominantly-solid.



- Calcification was not seen in any of the peritoneal nodules.
- Peritoneal cyst was seen in only 1 patient and who had malignant etiology.
- Scalloping was seen in 16.2% (n = 22) of the patients while 83.8% (n = 114) of the patients had no scalloping.
- Of the 64 patients with malignant etiology, 26.5% (n = 17) patients had scalloping, while 73.4% (n = 47) had no scalloping.
- Of the 72 patients with benign etiology, 6.9% (n = 5) had scalloping while 93.1% (n = 67) had no scalloping





Scalloping peritoneum	Malignant	Benign	OR (95% CI)	P- Value
Present	17 (26.56)	5 (6.94)	4.84 (1.67, 14.05)	0.001
Absent	47 (73.44)	67 (93.06)		

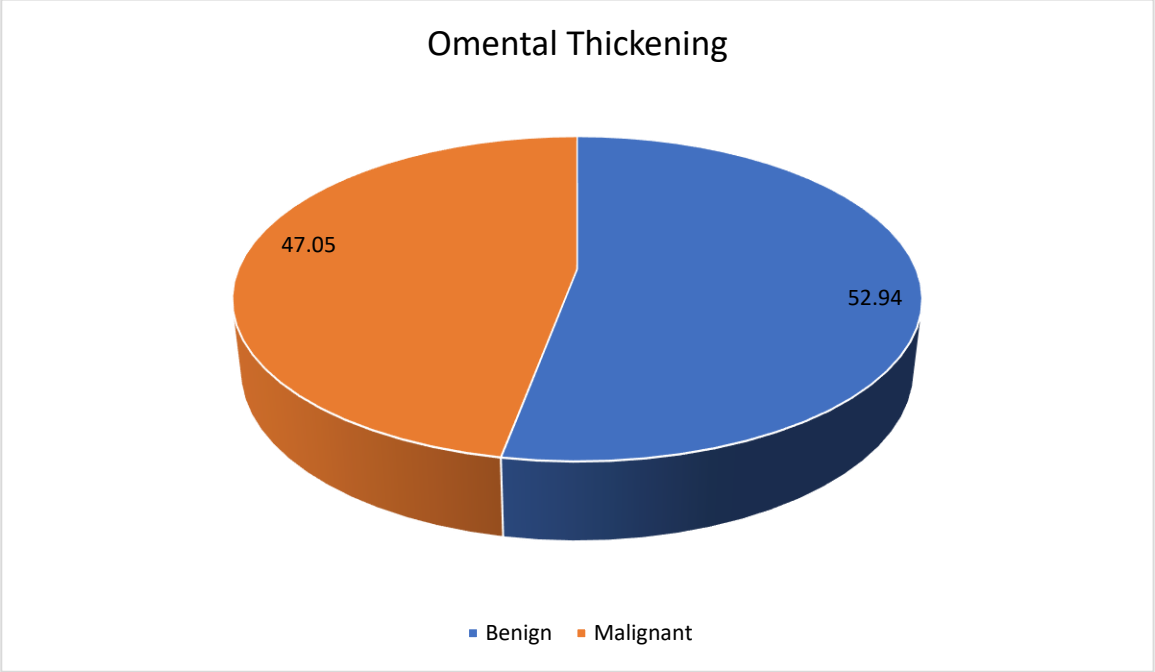
- The presence of scalloping had a statistically significant (p = 0.001) positive association with malignant etiology.

b. Omentum

- Thickened in all the 136 patients
- The mean thickness of omentum was 22.85 mm with a minimum of 4 mm and a maximum of 50 mm. The standard deviation was 8.85 mm.

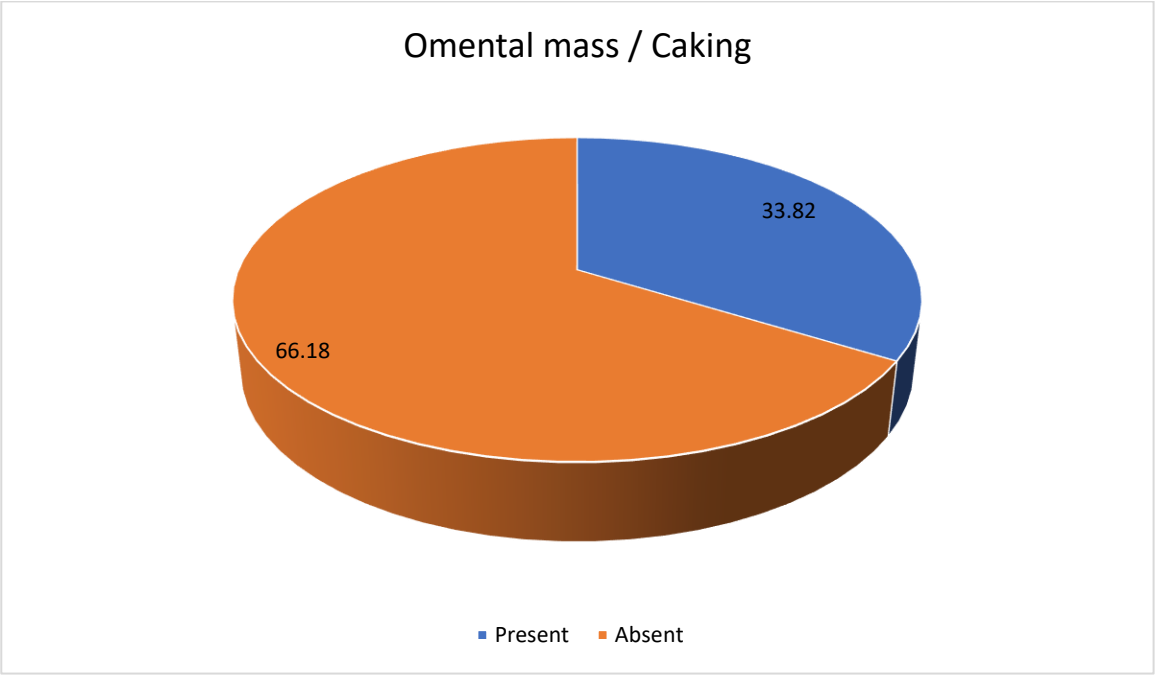
	Benign	Malignant	OR (95% CI)	P- Value
Omental thickness (mm)	20.69 +/- 6.96	25.28 +/- 10.09	**1.06 (1.02,1.11)**	0.004

- The thickness of omentum had a statistically significant (p = 0.004) positive association with malignant etiology.

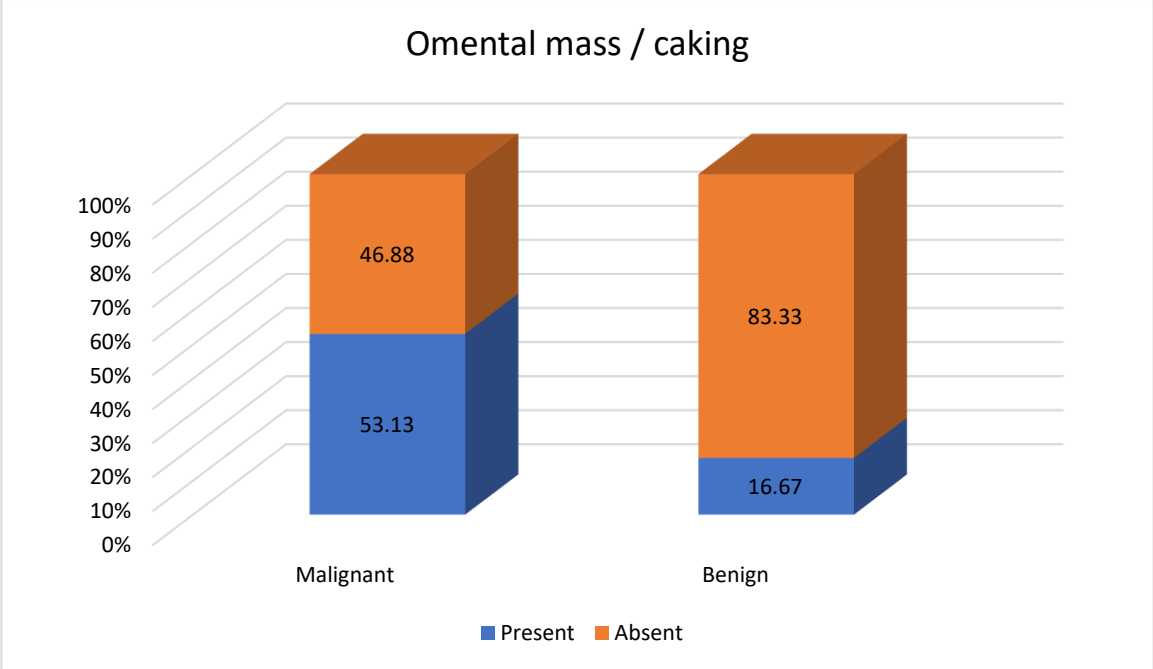


- Omental stranding was seen in 99.26% (135) of the patients.
  - Among the patients with malignant etiology, omental stranding was seen in 98.4% (n = 63) patients while 1.6% (n = 1) patient did not have omental stranding
  - All the 72 patients with benign etiology had omental stranding

- Omental mass / caking was seen in 33.8% (n = 46) of the total 136 patients, while 66.2 % (n = 90) had no omental mass / caking



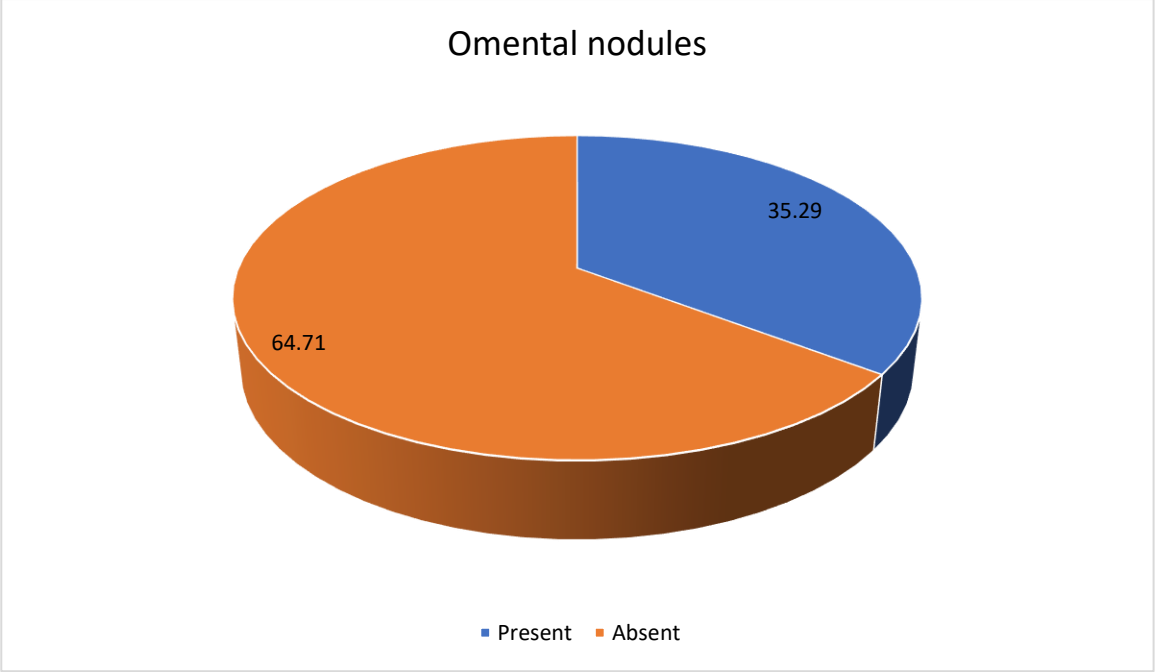
- Of the 64 patients with malignant etiology, 53.1% (n = 34) had omental mass/caking, while 46.9% (n = 30) did not
- Of the 72 patients with benign etiology, 16.6% (n = 12) patients had omental mass/caking, while 83.3% (n = 60) did not.



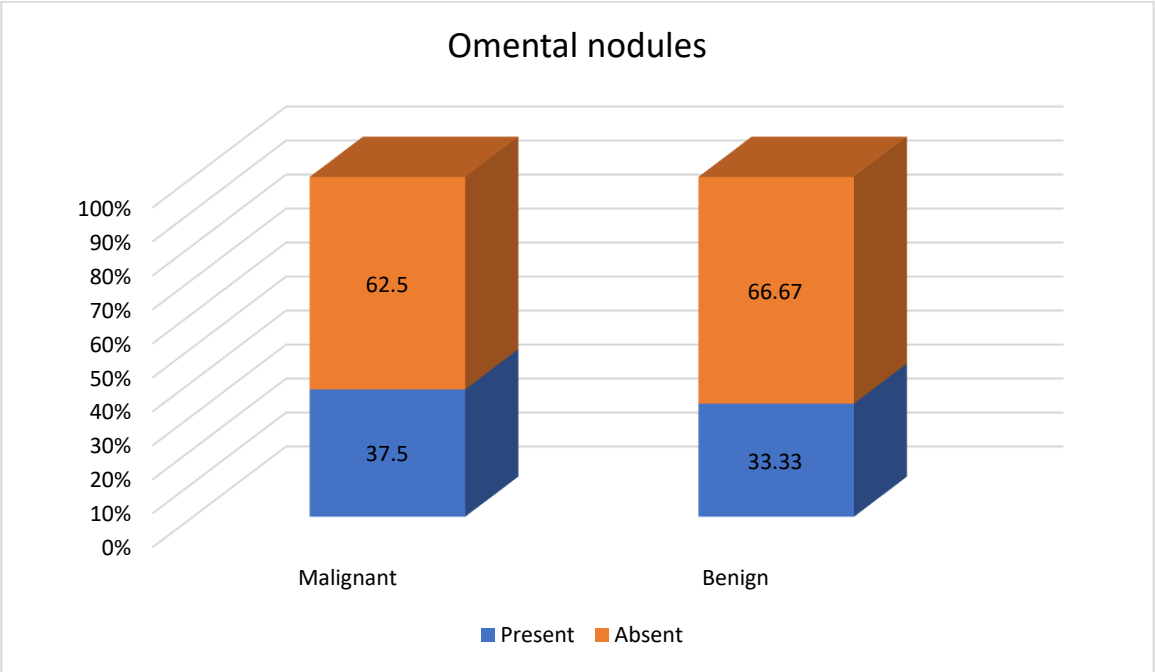
Omental mass / Caking	Malignant	Benign	OR (95% CI)	P- Value
Present	34 (53.13)	12 (16.67)	5.66 (2.57, 12.4)	0.000
Absent	30 (46.88)	60 (83.33)		

- The presence of omental mass/caking had a statistically significant (p = 0.000) positive association with malignant etiology.

- Omental nodules were seen 35.3% (n = 48) patients, while 64.7% (n = 88) did not have any omental nodules.



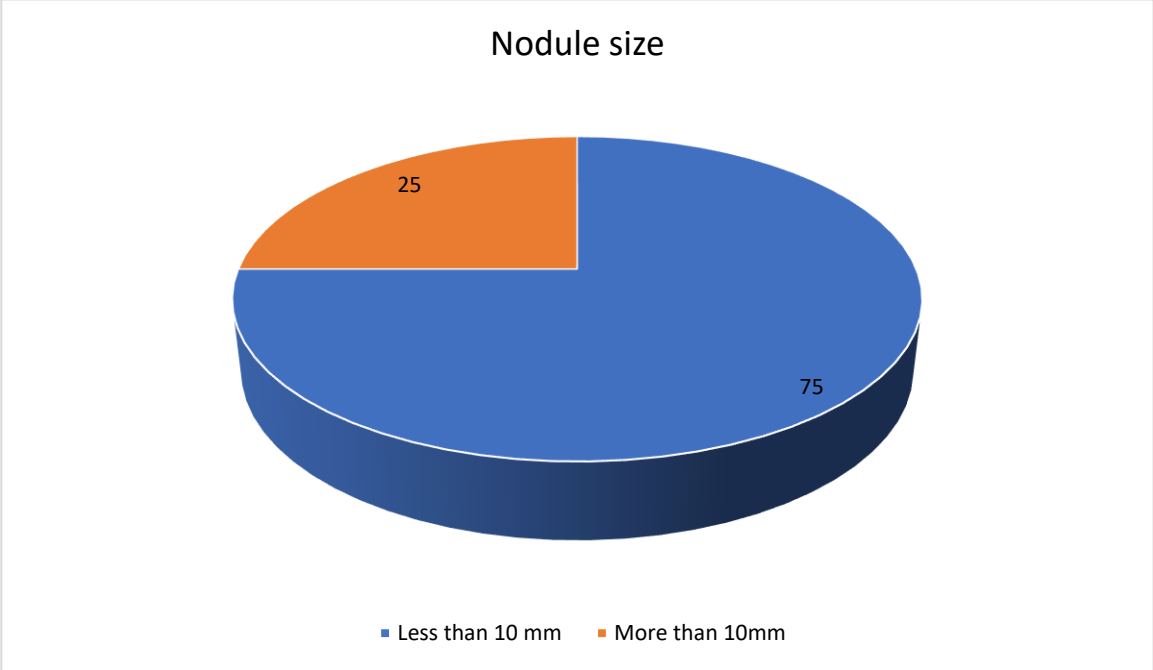
- Of the 64 patients with malignant etiology, 37.5% (n = 24) had omental nodules while 62.5% (n = 40) did not.
- Of the 72 patients with benign etiology, 33.3% (n = 24) had omental nodules while 66.7% (n = 48) did not.



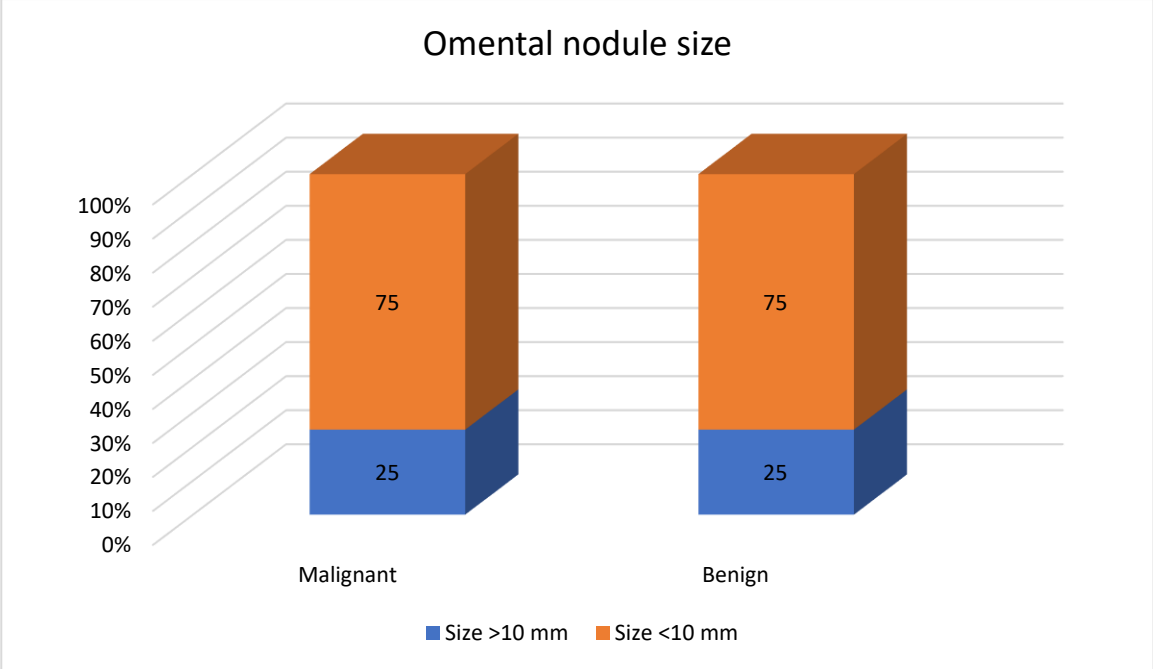
Omental nodules	Malignant	Benign	OR (95% CI)	P- Value
Present	24 (37.5)	24 (33.33)	1.2 (0.59, 2.42)	0.611
Absent	40 (62.5)	48 (66.67)		

- The presence of omental nodules did not contribute to differentiating malignant from benign etiology.

- Of the 48 patients with omental nodules, the size of the omental nodules was > 10 mm in 25% (n = 12) of the patient while 75% (n = 36) of the patients had nodules of size < 10 mm.



- Among the 24 patients with malignant etiology, 75% (n = 18) had omental nodules with size <10 mm, 25% (n = 6) had sizes >10 mm
- Among the 24 patients with benign etiology, 75% (n = 18) had omental nodules with size <10 mm, 25% (n = 6) had sizes >10 mm.

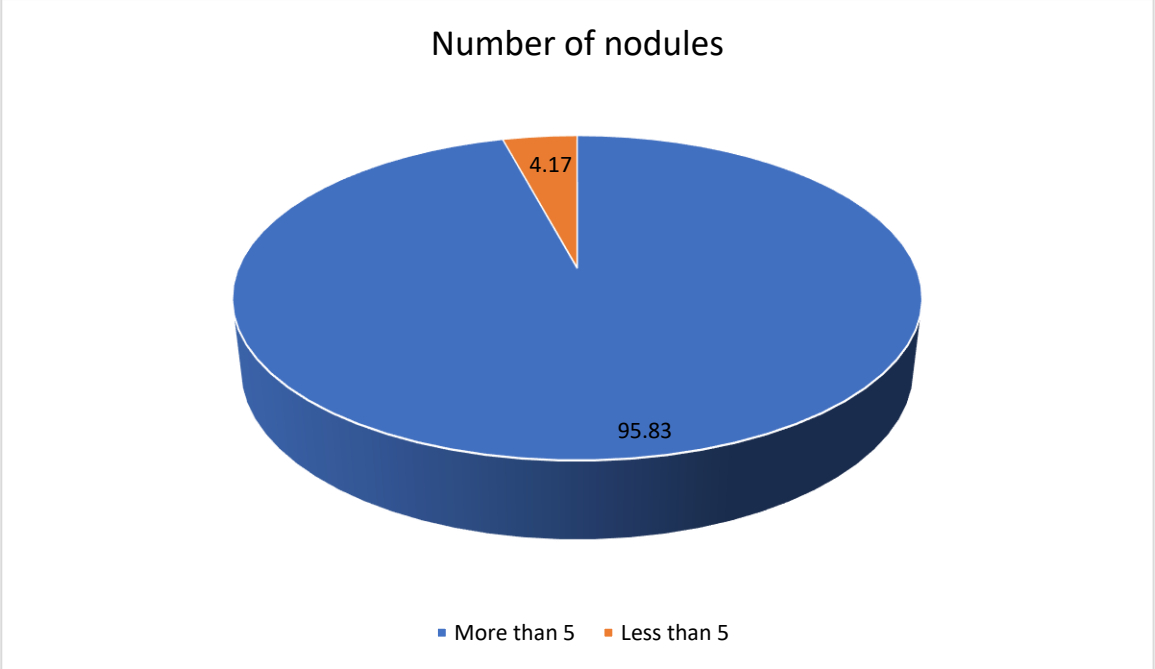


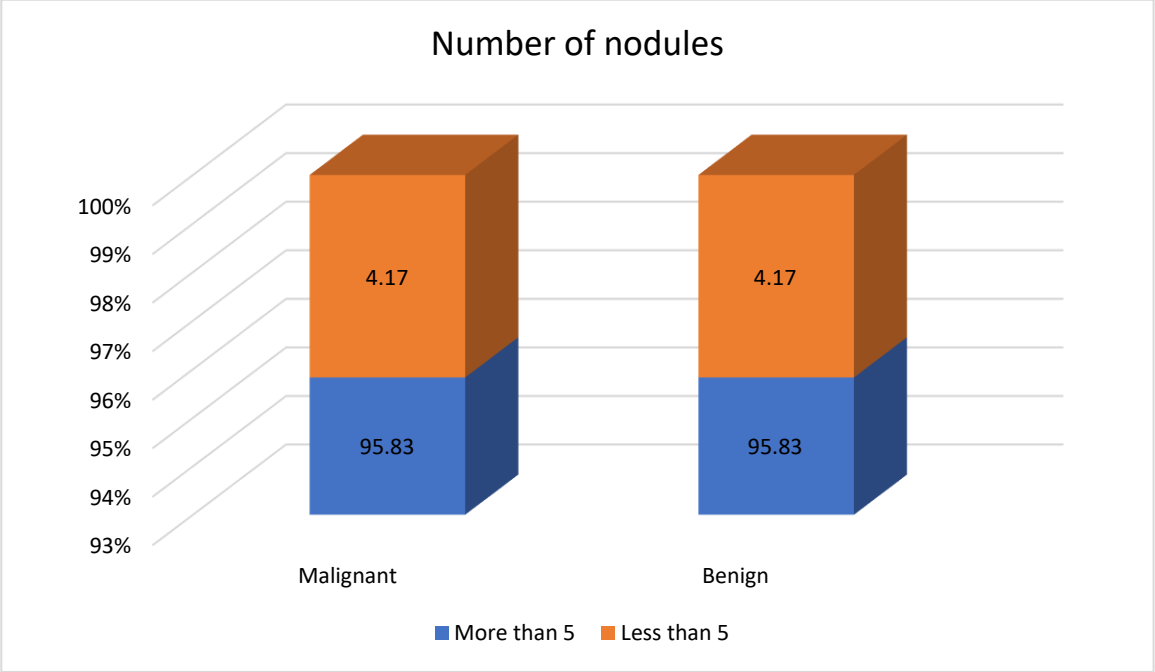
Omental Nodule size	Malignant	Benign	OR (95% CI)	P- Value
< 10 mm	18 (75)	18 (75)	1 (0.27, 3.69)	>0.99
>10 mm	6 (25)	6(25)		

- The size of omental nodules did not contribute to differentiating malignant from benign etiology.

- Out of the 24 patients with malignant etiology, 95.8% (n = 23) patients had omental nodules more than 5 in number, while 4.2 % (n = 1) patient had less than 5 nodules

- Similarly, among those with benign etiology, 95.8% (n = 23) patients had omental nodules more than 5 in number, while 4.2% (n = 1) patient had less than 5 nodules





- The number of omental nodules did not contribute to differentiating malignant from benign etiology.

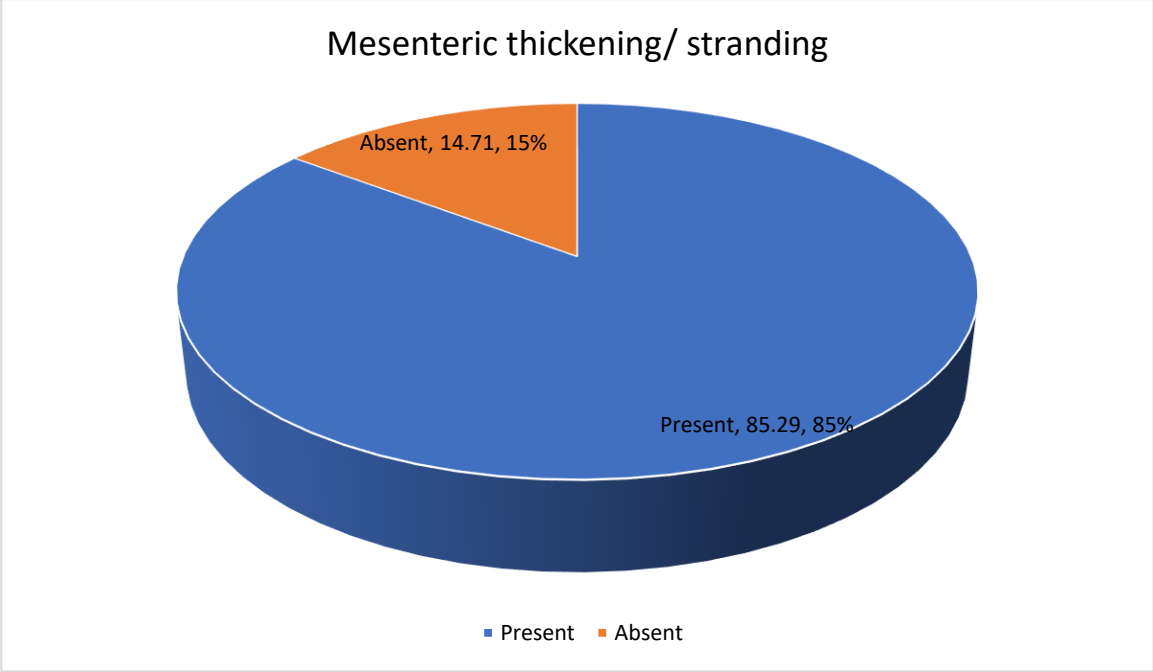
- The density of the omental nodules was predominantly-solid in 97.9% (n = 47) and mixed in 2.1% (n = 1) of the patients.

- Among the 24 patients with malignant etiology, the density of the peritoneal nodules was predominantly-solid in 95.8% (n = 23) patients, while 4.2% (n = 1) patient had mixed density
- All 24 patients with benign etiology had omental nodules of predominantly-solid density.

- Both benign and malignant etiology patients had one patient each with omental nodule calcification.

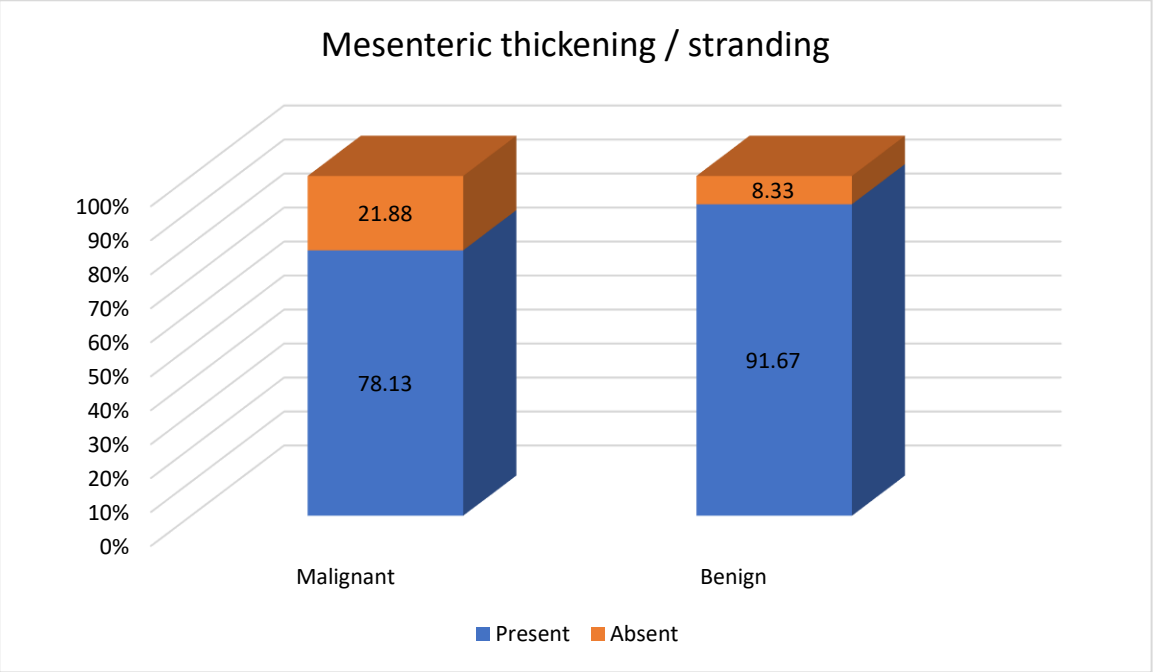
c. Mesentery

- Thickening and stranding of mesentery was seen in 85.3% (n = 116) of the patients, while 14.7% (n = 20) did not have these findings.



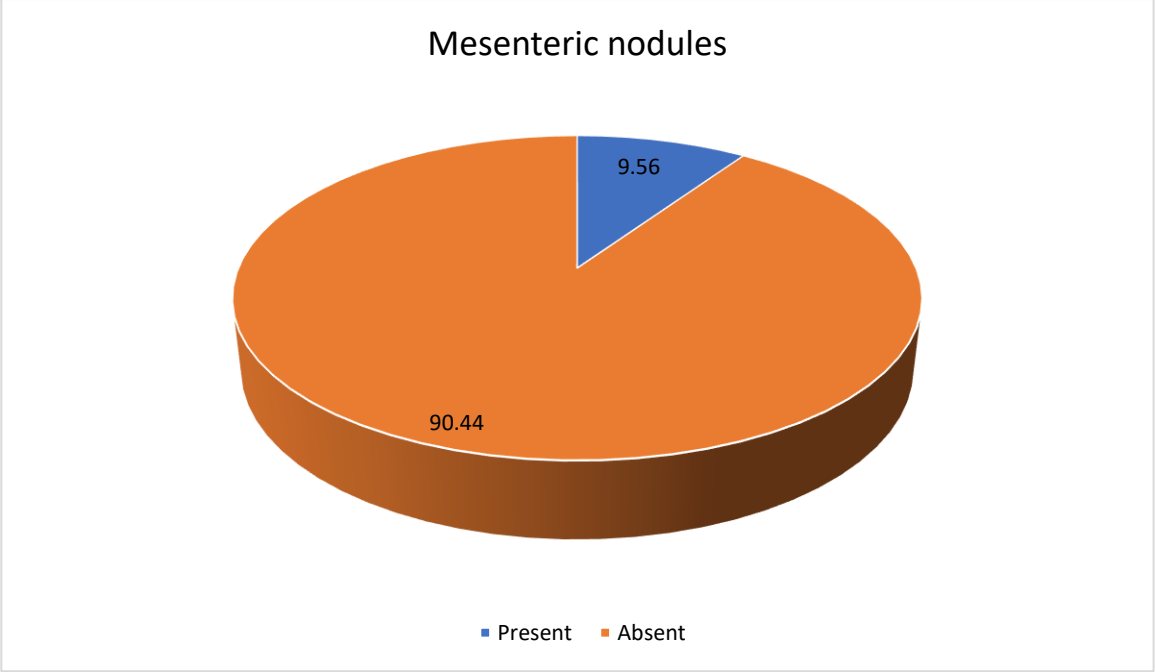
- Of the 64 patients with malignant etiology, 78.1% (n = 50) had thickening and stranding of mesentery while 21.9% (n = 14) did not have.

- Of the 72 patients with benign etiology 91.7% (n = 66) had mesenteric stranding / thickening while 8.3% (n = 6) did not have.

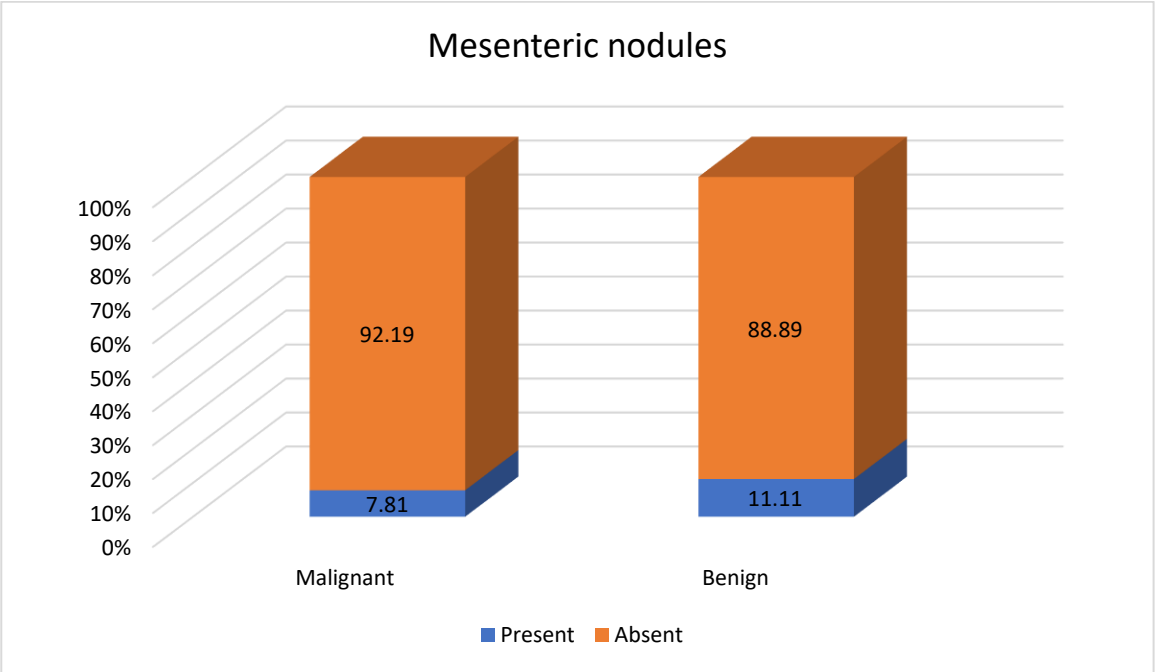


Mesenteric thickening/ stranding	Benign	Malignant	OR (95% CI)	P- Value
Present	66 (91.67)	50 (78.13)	3.08 (1.1, 8.5)	0.026
Absent	6 (8.33)	14 (21.88)		

- The presence of mesenteric thickening/stranding had a statistically significant (p = 0.026) association with benign etiology.
- Mesenteric mass was seen in only 2.2% (n = 3) of the 136 patients. All three were of malignant etiology.
- Mesenteric nodules were seen in 9.6% (n = 13) while 90.4% (n = 123) had no mesenteric nodules.



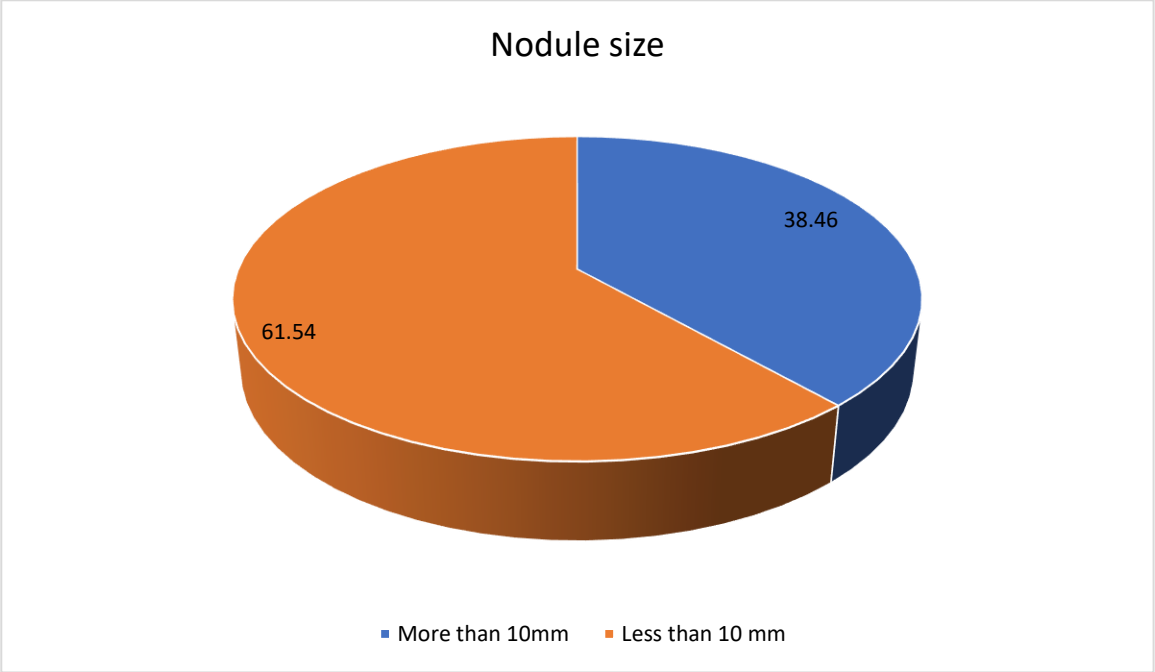
- Of the 64 patients with malignant etiology, 7.8% (n = 5) had mesenteric nodules while 92.2% (n = 59) did not.
- Of the 72 patients with benign etiology, 11.1% (n = 8) had mesenteric nodules while 88.9% (n = 64) did not.

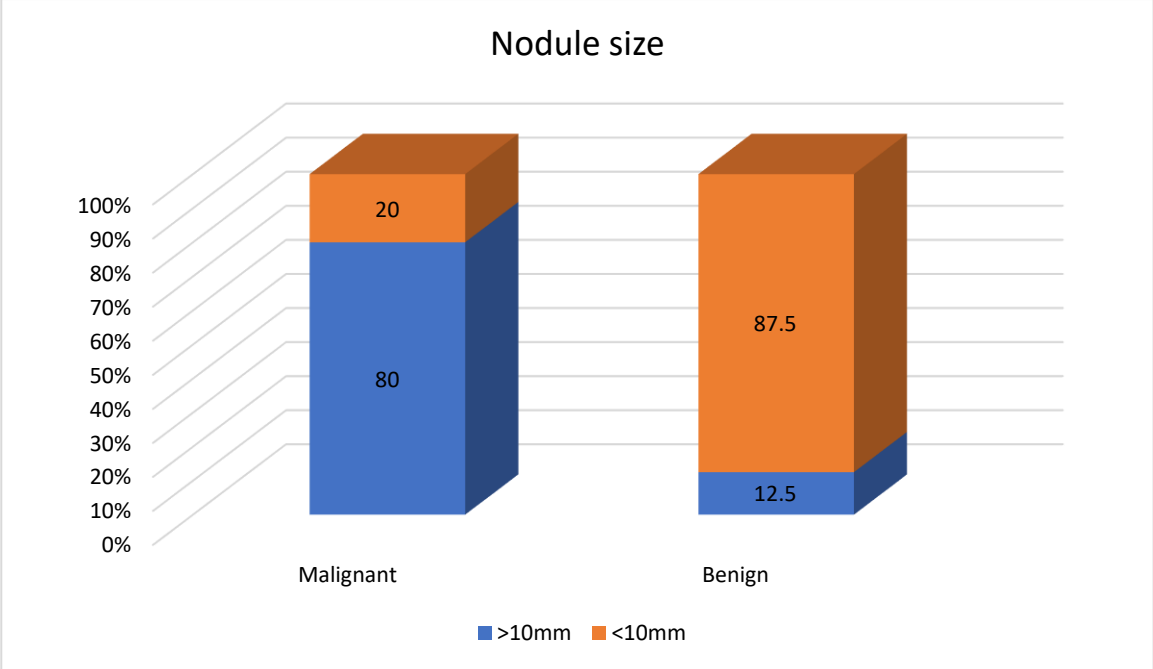


Mesenteric nodules	Malignant	Benign	OR (95% CI)	P- Value
Present	5 (7.81)	8 (11.11)	0.67 (0.20, 2.18)	0.513
Absent	59 (92.19)	64 88.89)		

- The presence of mesenteric nodules did not contribute to differentiating malignant from benign etiology.

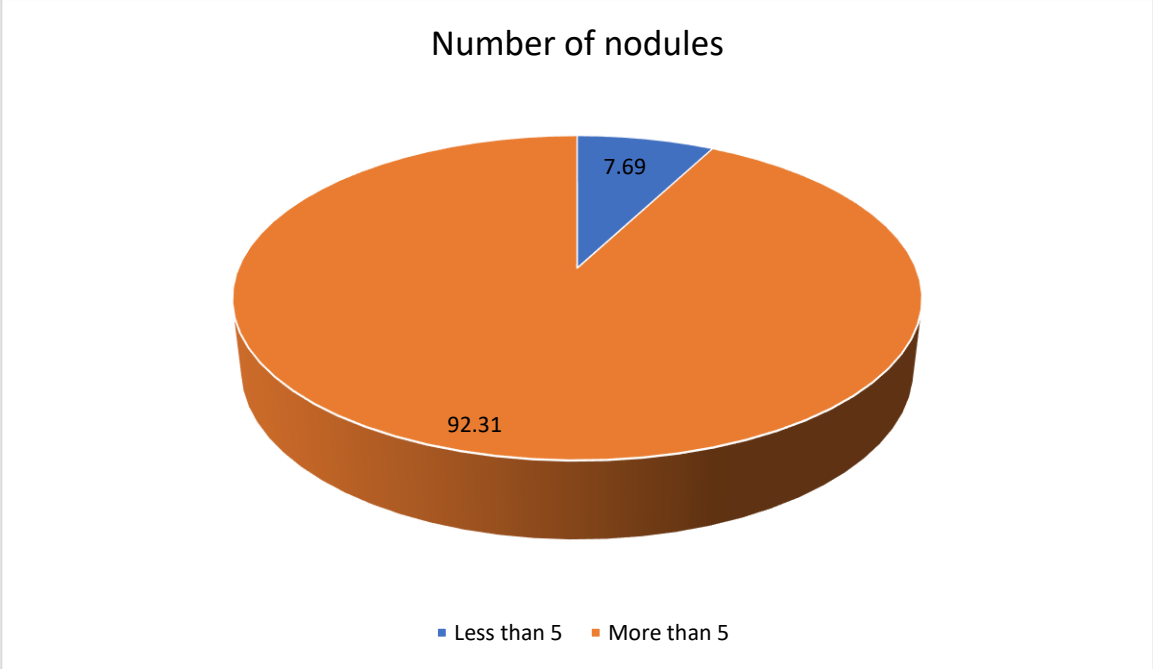
- Of the 5 patients with malignant etiology, 20% (n = 1) had mesenteric nodules of sizes less than 10 mm while 80% (n = 4) were of sizes more than 10mm.
- Among the 8 patients with benign etiology, 87.5% (n = 7) had nodules of sizes less than 10mm, while 12.5% (n = 1) had nodules of sizes more than 10 mm





Size of mesentery nodules	Malignant	Benign	OR (95% CI)	P- Value
>10mm	4 (80)	1 (12.5)	28 (1.3, 580.6)	0.014
<10 mm	1 (20)	7 (87.5)		

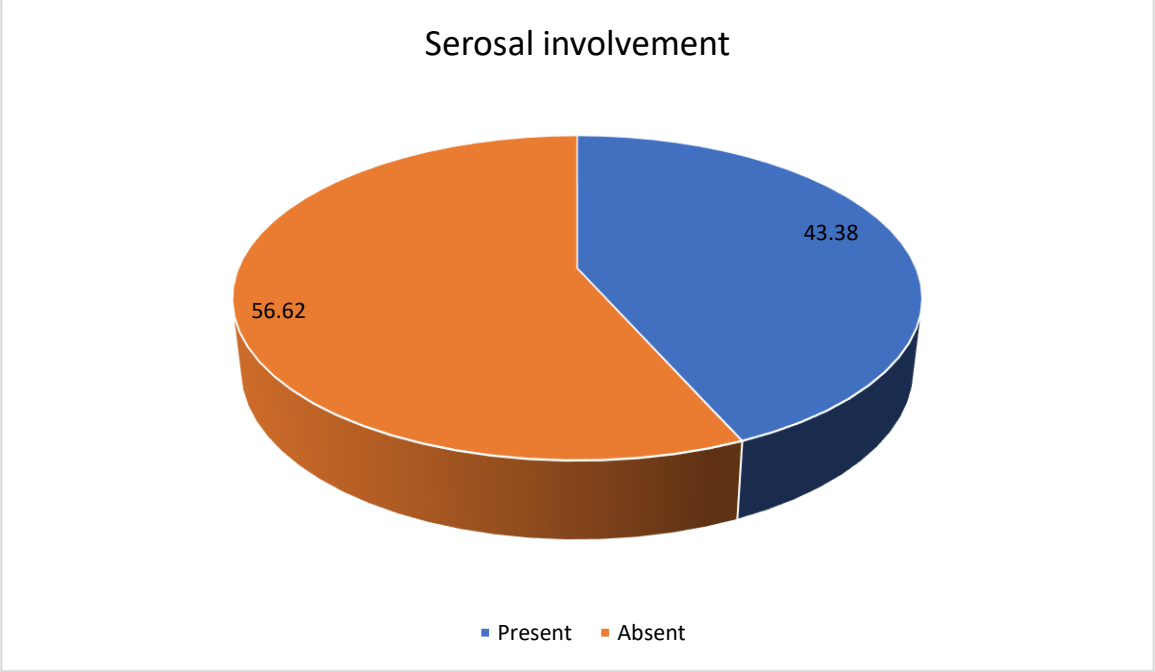
- The presence of mesenteric nodules of sizes >10 mm had a statistically significant (p = 0.014) positive association with malignant etiology.
- The number of nodules were less than 5 in 7.7% (n = 1) while 92.3% (n = 12) patient had more than 5 nodules.



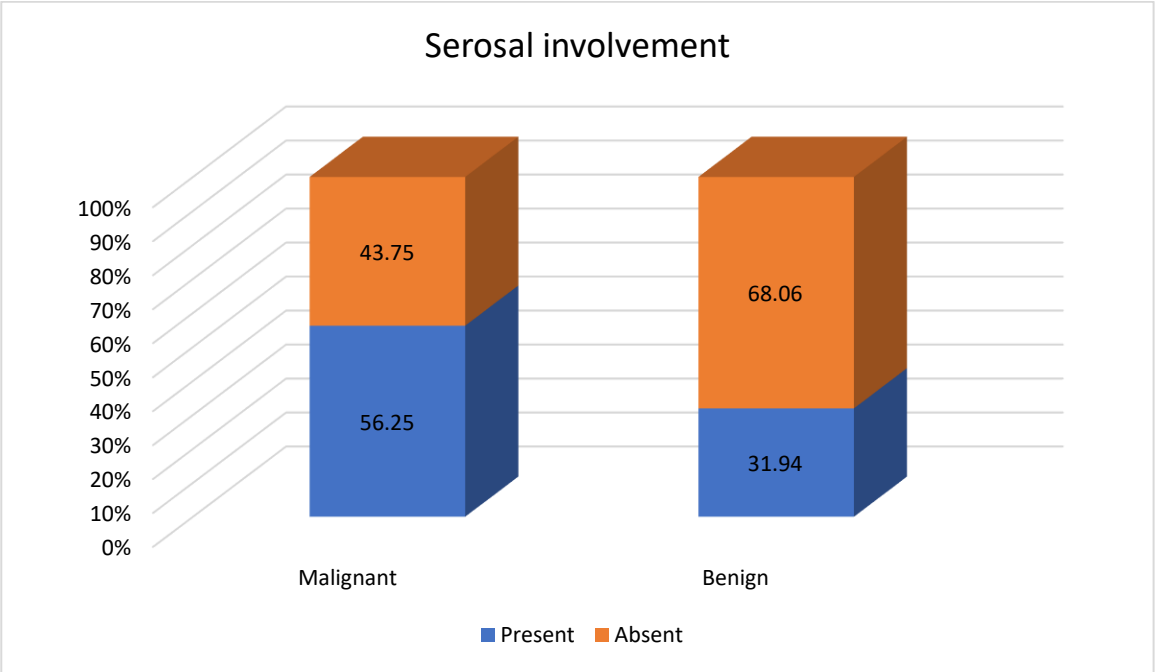
- Of the 5 patients with malignant etiology, 80% (n = 4) had mesenteric nodules more than 5, while 20% (n = 1) had nodules less than 5 in number
- All the 8 patients with benign etiology had more than 5 nodules
- The mesenteric nodules did not show any calcification

d) Serosal involvement

- Serosal involvement was seen in 43.4% (n = 59) of the patients, while 56.6% (n = 77) did not show any serosal involvement



- Among the 64 cases who had malignant etiology, 56.2% (n = 36) had serosal involvement while 43.7% (n = 28) had none
- Among the 72 who had benign etiology, 31.9% (n = 23) had serosal implants while 68.1% (n = 49) had none

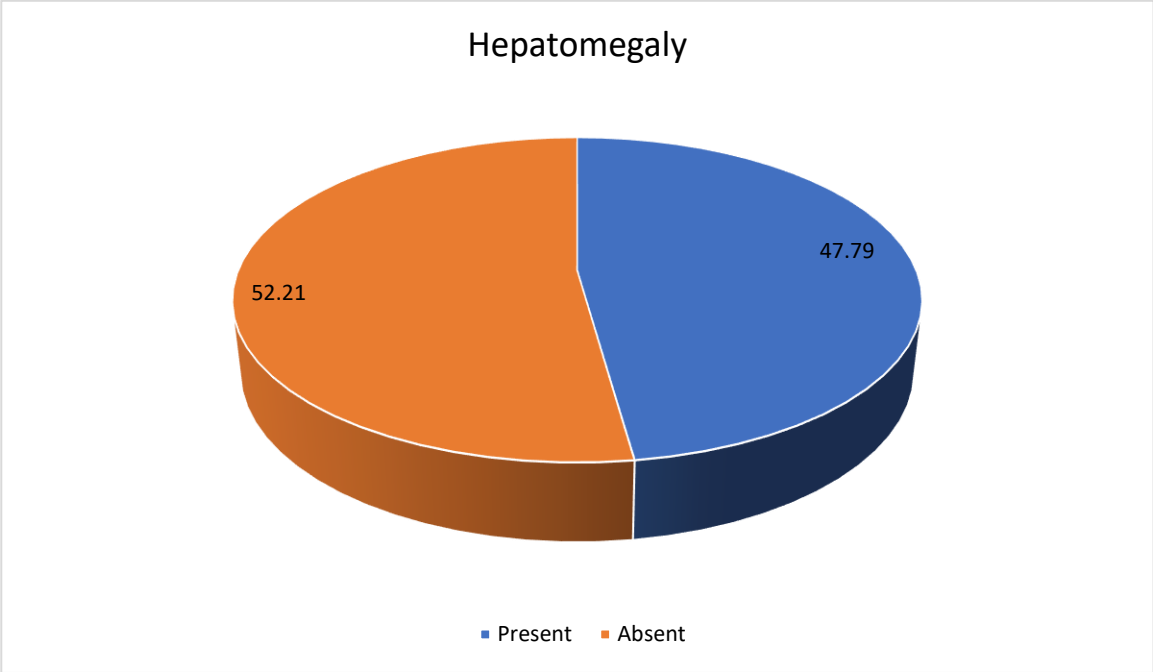


Serosal involvement	Malignant	Benign	OR (95% CI)	P- Value
Present	36 (56.25)	23 (31.94)	2.73 (1.36, 5.51)	0.0043
Absent	28 (43.75)	49 (68.06)		

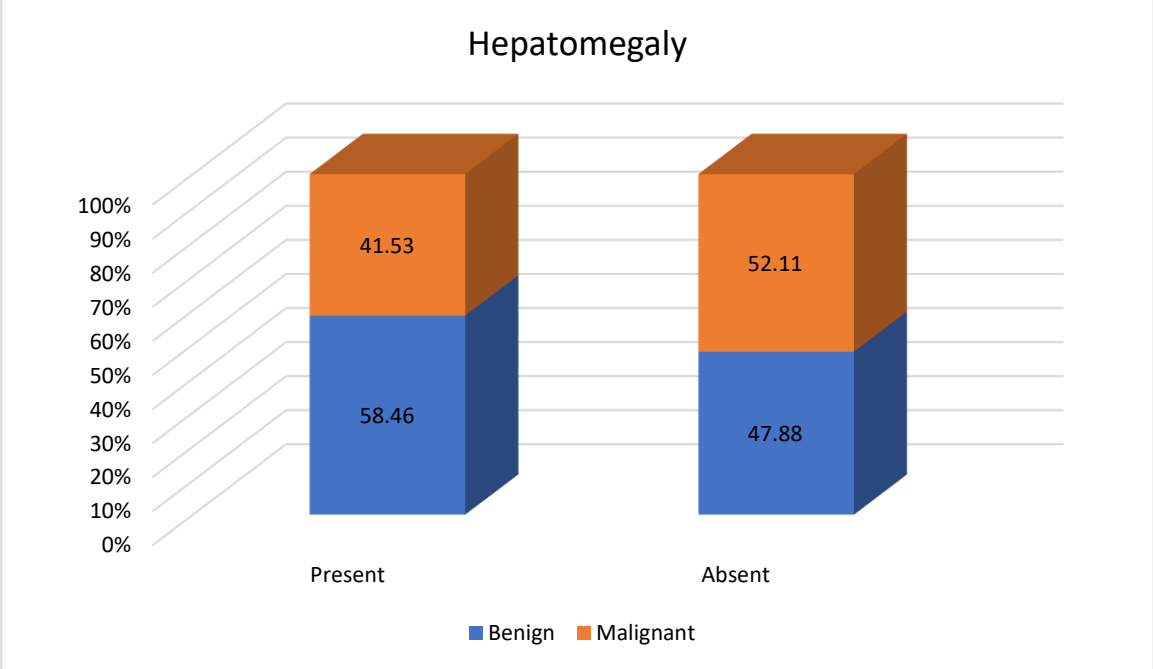
- Serosal involvement had a statistically significant (p = 0.004) positive association with malignant etiology.

e) Liver involvement

- Liver was enlarged in 47.8% (n = 65) of the patients, while 52.2% (n = 71) had normal size of the liver.

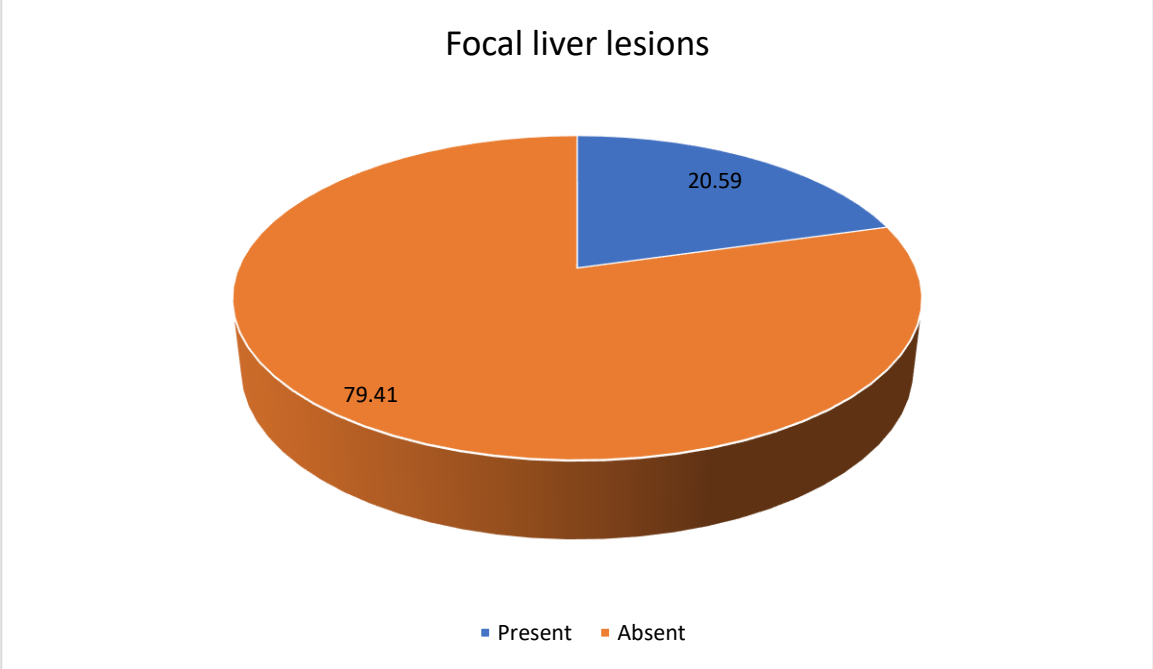


- Among the 64 cases who had malignant etiology, 42.2% (n = 27) patients had hepatomegaly while 57.8% (n = 37) did not.
- Among the 72 patients who had benign etiology, 52.8% (n = 38) patients had hepatomegaly while 47.2% (n = 34) did not.

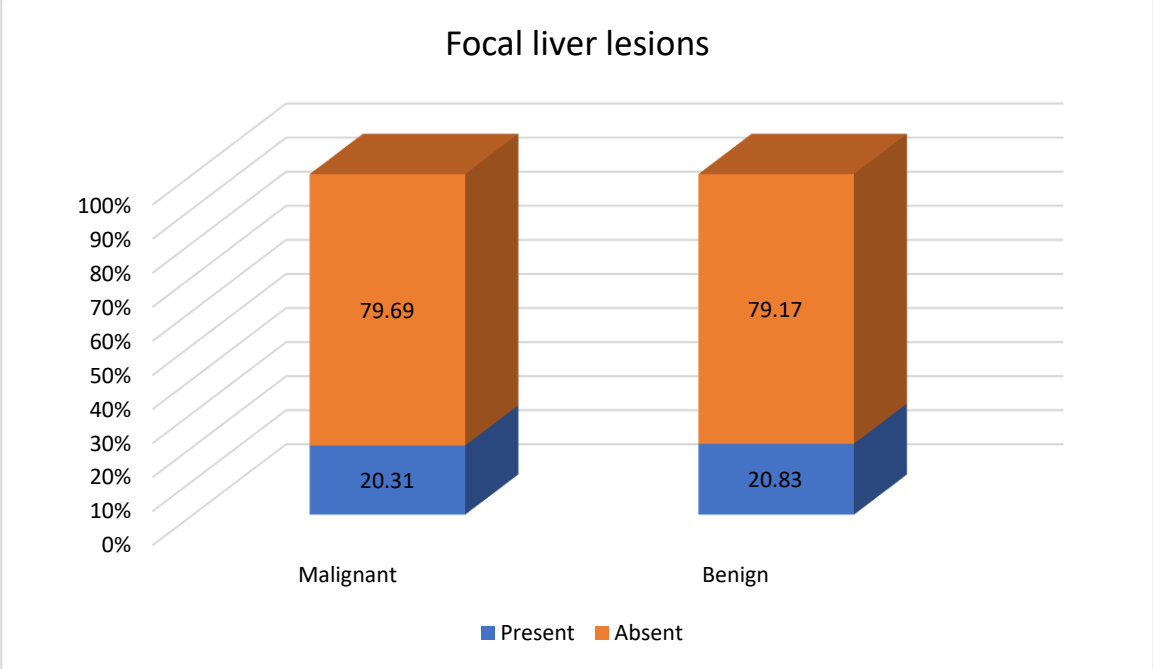


Hepatomegaly	Malignant	Benign	OR (95% CI)	P- Value
Present	27 (42.19)	38 (52.78)	0.65 (0.33, 1.28)	0.217
Absent	37 (57.81)	34 (47.22)		

- The presence of hepatomegaly did not contribute to differentiating malignant from benign etiology.
- Focal liver lesions were seen in 20.6% (n = 28) of the patients, while 79.4% (n = 108) had no focal liver lesions.



- Among the 64 cases who had malignant etiology, focal liver lesions were seen in 20.3% (n = 13) patients while 79.7% (n = 51) patients did not.
- Among the 72 patients who had benign etiology, 20.8% (n = 15) patients had focal liver lesions while 79.2% (n = 57) patients did not have any

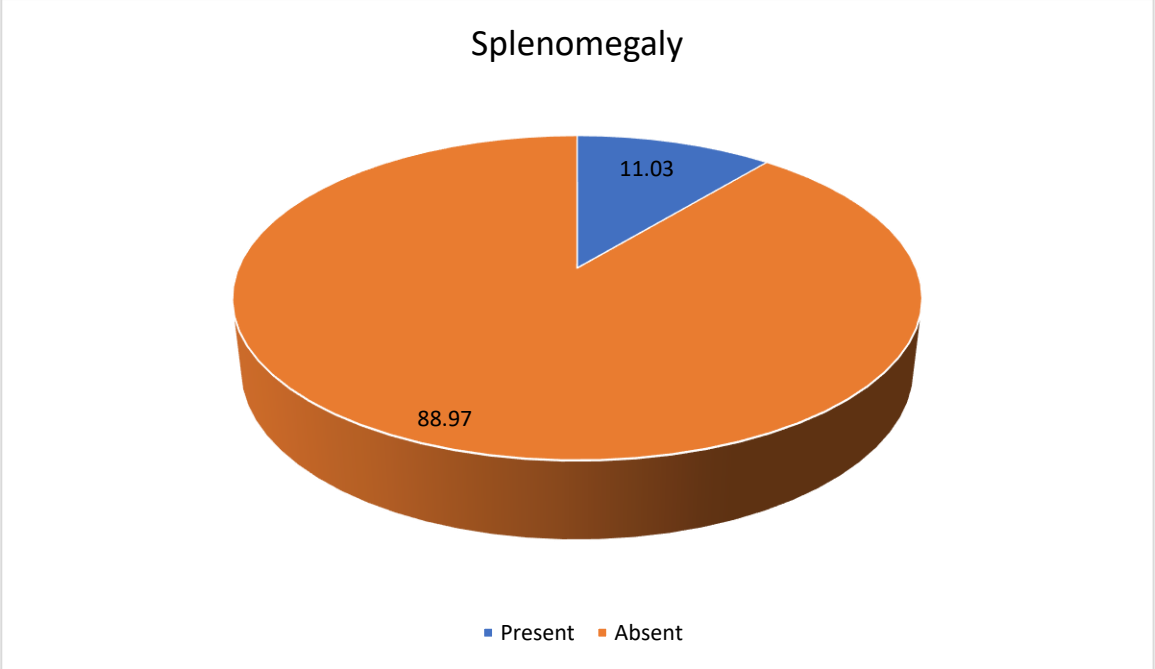


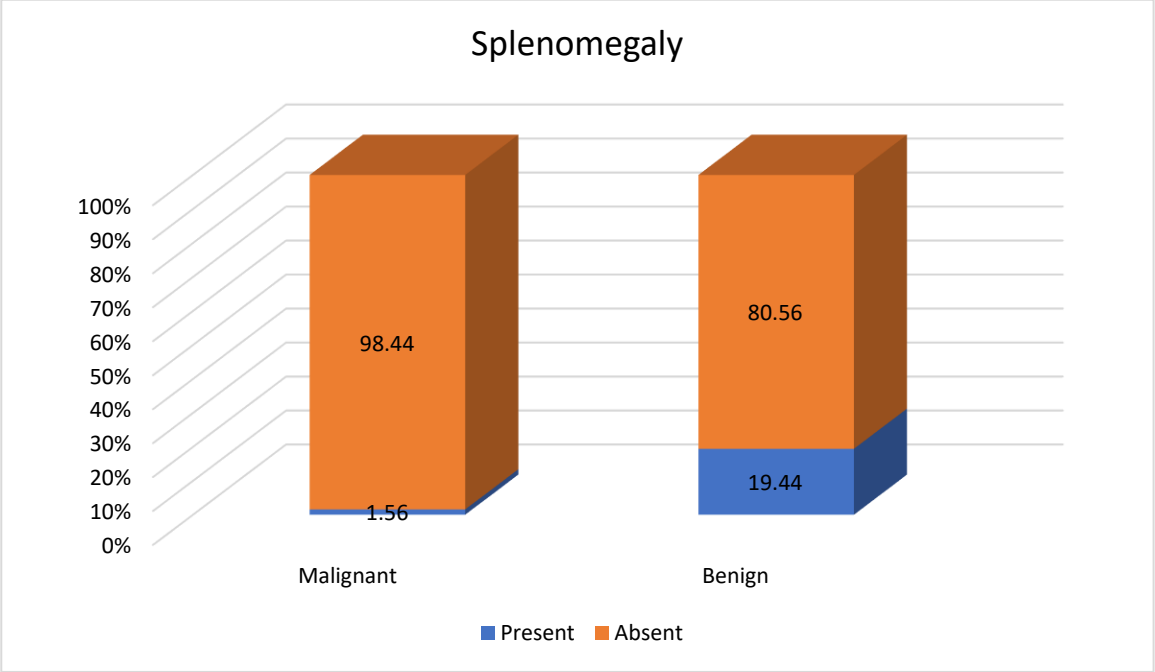
Focal lesions in liver	Malignant	Benign	OR (95% CI)	P- Value
Present	13 (20.31)	15 (20.83)	0.96 (0.42, 2.22)	0.940
Absent	51 (79.69)	57 (79.17)		

- The presence of focal liver lesions did not contribute to differentiating malignant from benign etiology.
- Of the 64 patients with malignant etiology, only 1 patient had IHBRD
- None of the patients with benign etiology had IHBRD

f) Splenic involvement

- Spleen was enlarged in 11.03% (n = 15) of the patients while 88.97% (n = 121) had no splenomegaly.
- Of the 64 patients with malignant etiology, 1.6% (n = 1) patient had splenomegaly while 98.4% (n = 63) patients did not
- Among the 72 patients with benign etiology, splenomegaly was seen in 19.4% (n = 14) patients while 80.6% (n = 58) did not.

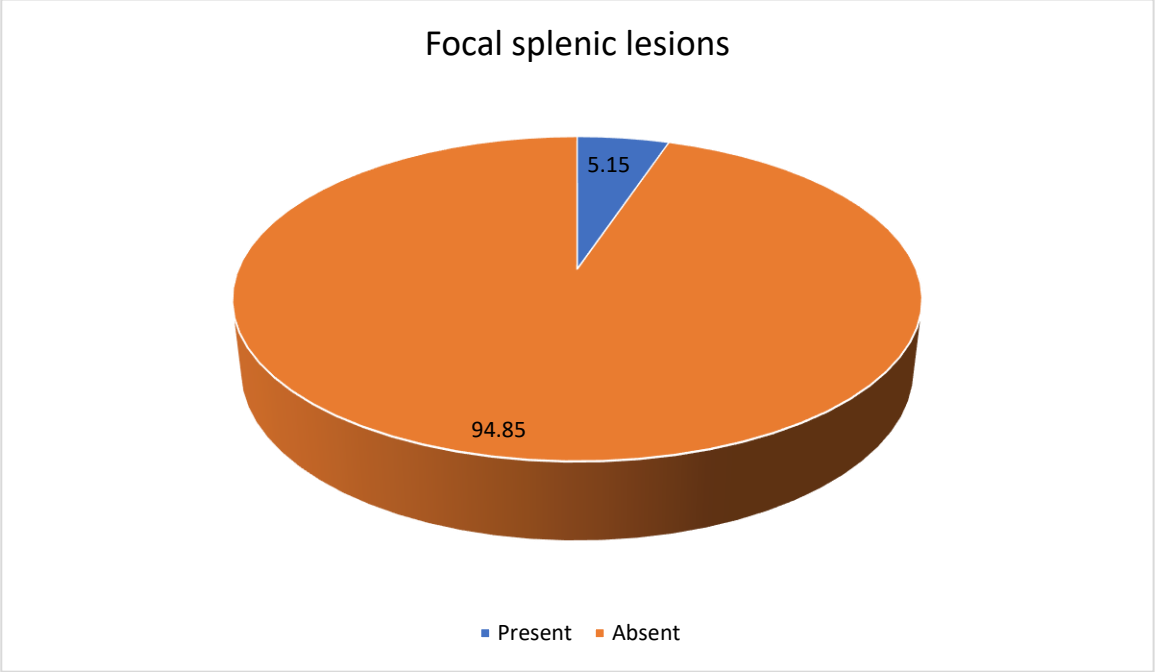


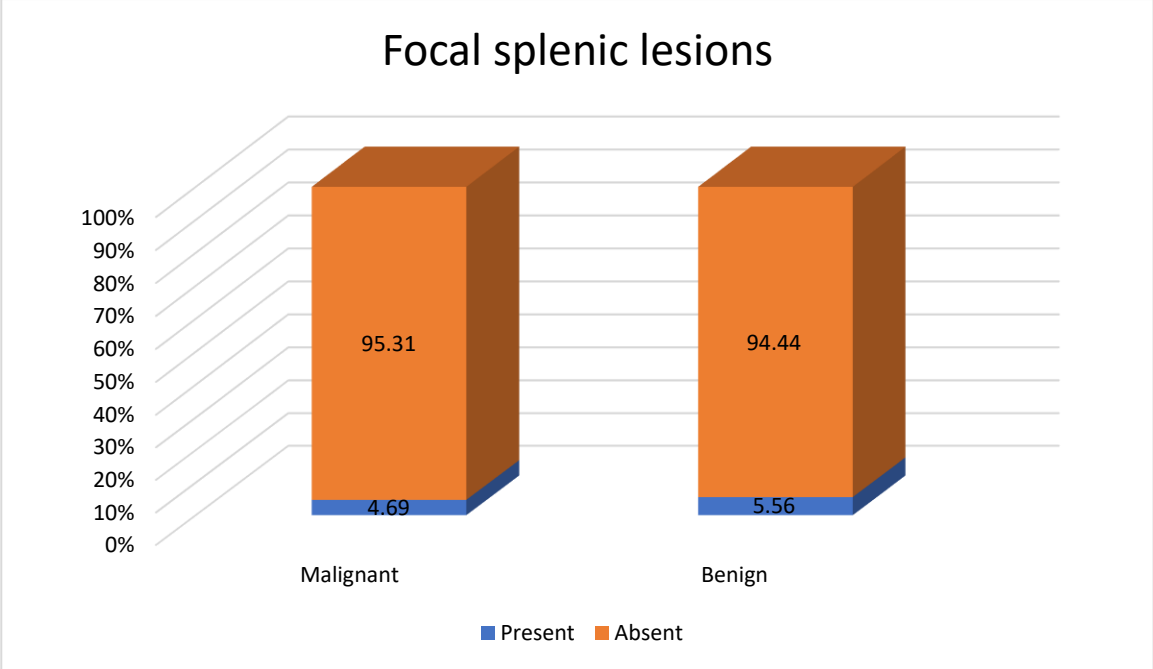


Splenomegaly	Benign	Malignant	OR (95% CI)	P- Value
Present	14 (19.44)	1 (1.56)	15.20 (1.9, 119.3)	<0.001
Absent	58 (80.56)	63 98.44)		

- Presence of splenomegaly had a statistically significant (p = <0.001) positive association with benign etiology.

- Focal lesions in spleen were seen in 5.15% (n = 7) of the patients, while 94.8% (n = 129) had no focal splenic lesions.
  - Of the 64 patients with malignant etiology, 4.7% (n = 3) patients had focal lesions in the spleen while 95.3% (n = 61) patients did not.
  - Among the 72 patients with benign etiology, 5.6% (n = 4) patients had focal splenic lesions while 94.4 (n = 68) patients did not.



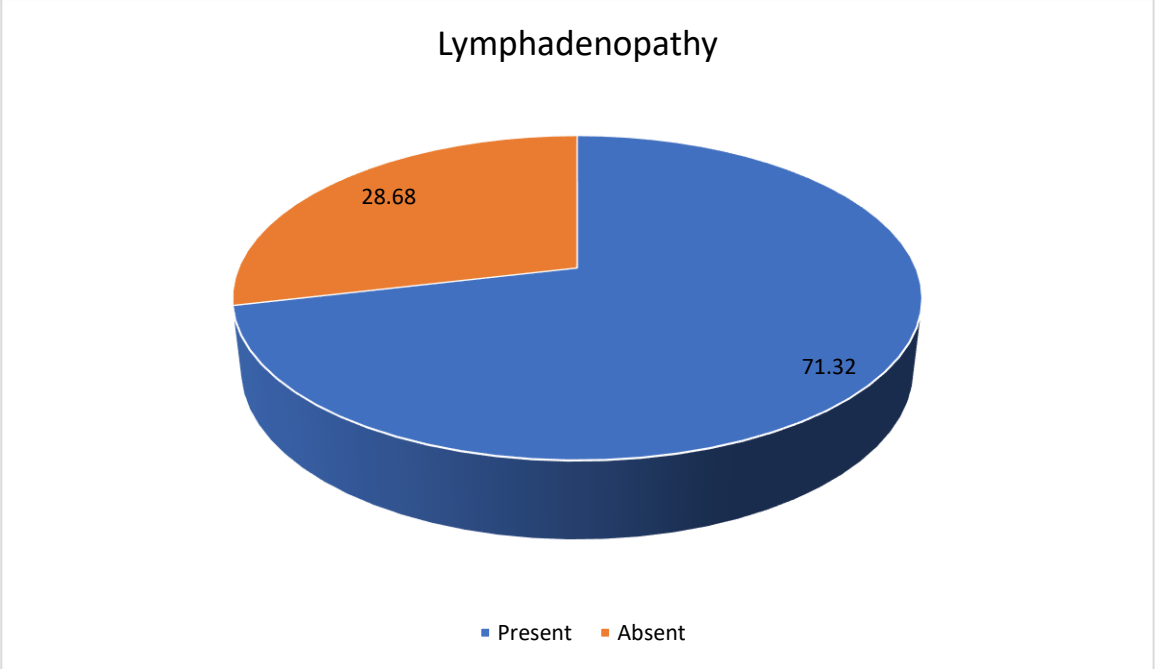


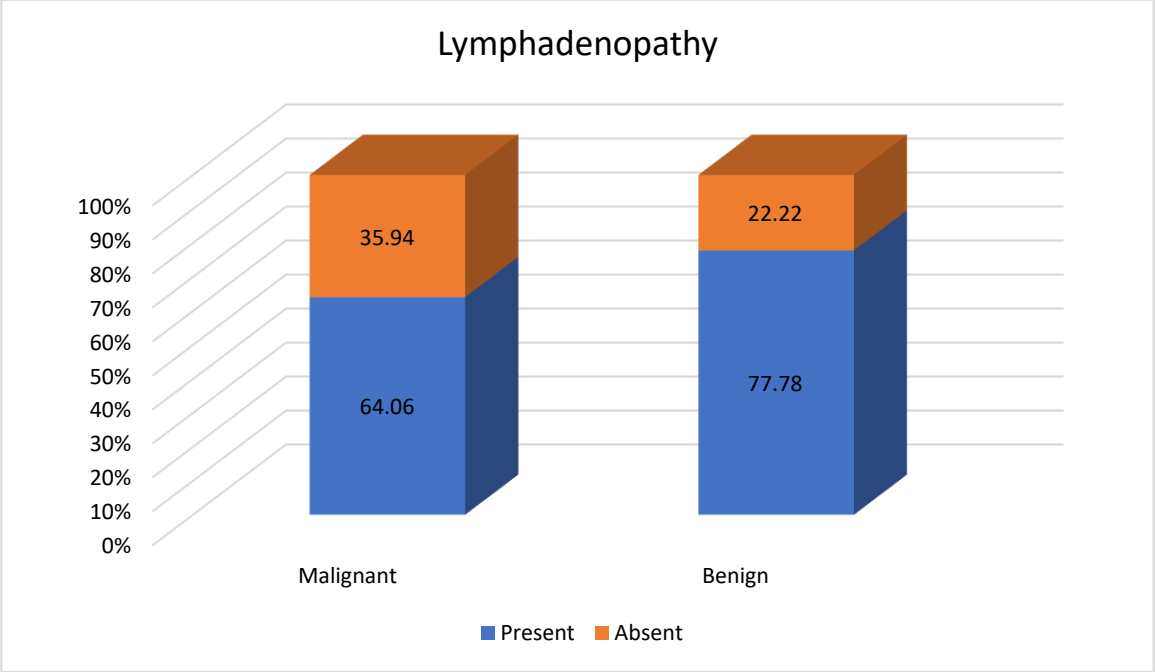
Focal splenic lesions	Malignant	Benign	OR (95% CI)	P- Value
Present	3(4.69)	4 (5.56)	0.83 (0.17, 3.88)	0.819
Absent	61(95.31)	68 (94.44)		

- Presence of focal splenic lesions did not contribute to differentiating malignant from benign etiology.

g) Lymphadenopathy

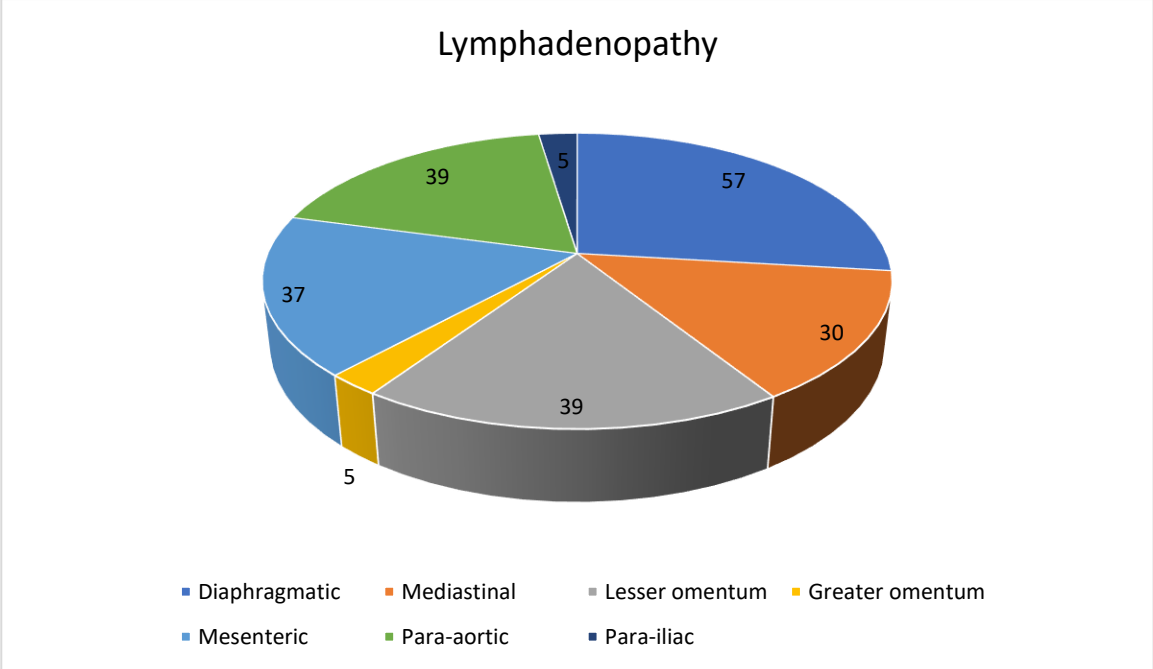
- Enlarged lymph nodes were seen in 71.3% (n = 97) of the patients while 28.7% (n = 39) had no lymphadenopathy.
- Of the 64 patients with malignant etiology, 64.0% (n = 41) patients had lymphadenopathy while 35.9% (n = 23) patients did not
- Of the 72 patients with benign etiology, 77.8% (n = 56) patients had lymphadenopathy, while 22.2% (n = 16) patients did not





Lymphadenopathy	Malignant	Benign	OR (95% CI)	P- Value
Present	41 (64.06)	56 (77.78)	0.50 (0.23, 1.08)	0.077
Absent	23 (35.94)	16 (22.22)		

There was no significant difference in the presence or absence of lymphadenopathy between benign and malignant etiologies of peritoneal disease.



- **Diaphragmatic nodes**

  - Of the 41 patients with lymphadenopathy who had malignant etiology, 51.2% (n = 21) had significant diaphragmatic adenopathy while 48.8% (n = 20) did not.
  - Of the 56 with benign etiology, 64.3% (n = 36) had significant diaphragmatic adenopathy while 35.7% (n = 20) did not

Diaphragmatic adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	21 (51.22)	36 (64.29)	0.58(0.25, 1.3)	0.19
Absent	20 (48.78)	20 35.71)		

The presence of diaphragmatic lymphadenopathy did not contribute in differentiating malignant from benign etiology.

- **Mediastinal adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 26.8% (n = 11) had significant mediastinal adenopathy while 73.1% (n = 30) did not.
- Of the 56 with benign etiology, 33.9% (n = 19) had significant mediastinal adenopathy while 66.1% (n = 37) did not.

Mediastinal adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	11 (26.83)	19 (33.93)	0.71(0.29,1.73)	0.45
Absent	30 (73.17)	37 (66.07)		

The presence of mediastinal lymphadenopathy did not contribute in differentiating malignant from benign etiology.

- **Lesser omental adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 39.02% (n = 16) had significant lesser omental adenopathy while 60.98% (n = 25) did not.
- Of the 56 with benign etiology, 41.1% (n = 23) had significant lesser omental adenopathy while 58.9% (n = 33) did not.

Lesser omental adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	16 (39.02)	23 (41.07)	0.91(0.4, 2.0)	0.839
Absent	25 (60.98)	33 (58.93)		

The presence of lesser omental lymphadenopathy did not contribute in differentiating malignant from benign etiology.

- **Greater omental adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 2.4% (1) had significant greater omental adenopathy while 97.6% (n = 40) did not.
- Of the 56 with benign etiology, 7.1% (n = 4) had significant greater omental adenopathy while 92.9% (n = 52) did not.

Greater omental adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	1 (2.44)	4 (7.14)	0.32(0.03,3.02)	0.323
Absent	40 (97.56)	52 92.86)		

The presence of greater omental lymphadenopathy did not contribute in differentiating malignant from benign etiology.

- **Mesenteric adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 17.1% (n = 7) had significant mesenteric adenopathy while 82.9% (n = 34) did not.
- Of the 56 with benign etiology, 53.6% (n = 30) had significant mesenteric adenopathy while 46.4% (n = 26) did not.

Mesenteric adenopathy	Benign	Malignant	OR (95%CI)	P- value
Present	30 (53.57)	7 (17.07)	5.60(2.12,14.75)	0.0005
Absent	26 (46.43)	34 (82.93)		

The presence of mesenteric lymphadenopathy had a statistically significant (p = 0.0005) association with benign etiology.

- **Para-aortic adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 34.15% (n = 14) had significant para-aortic adenopathy while 65.85% (n = 27) did not.
- Of the 56 with benign etiology, 44.6% (n = 25) had significant para-aortic adenopathy while 55.4% (n = 31) did not.

Para-aortic adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	14 (34.15)	25 (44.64)	0.64(0.27,1.47)	0.298
Absent	27 (65.85)	31 55.36)		

The presence of para-aortic lymphadenopathy did not contribute in differentiating malignant from benign etiology.

- **Para-iliac adenopathy**

- Of the 41 patients with lymphadenopathy who had malignant etiology, 7.3% (n = 3) had significant para-iliac adenopathy while 92.7% (n = 38) did not.
- Of the 56 with benign etiology, 3.6% (n = 2) had significant para-iliac adenopathy while 96.4% (n = 54) did not.

Para-iliac adenopathy	Malignant	Benign	OR (95%CI)	P- value
Present	3 (7.32)	2 (3.57)	2.09(0.33,13.13)	0.431
Absent	38 (92.68)	53 96.43)		

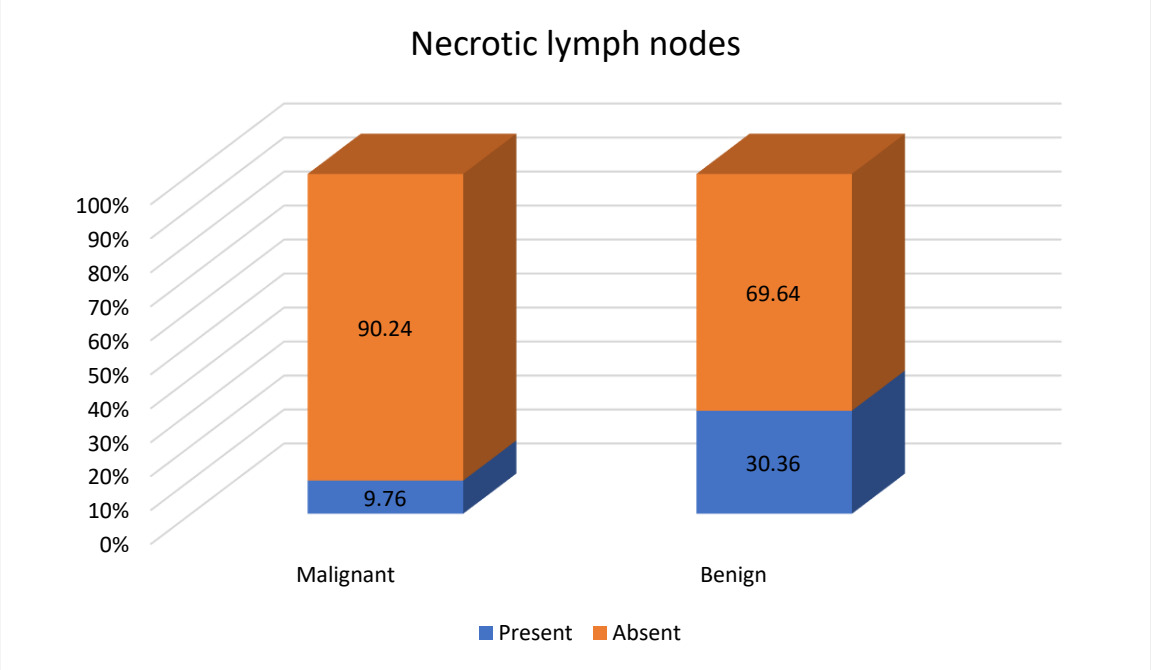
The presence of para-iliac lymphadenopathy did not contribute in differentiating malignant from benign etiology.

h) Necrotic lymph nodes

Necrotic lymph nodes were seen in 21.65% (n = 21) of the 97 patients with lymphadenopathy while 78.35% (n = 76) patients did not have necrotic lymph nodes

- Of the 41 patients with lymphadenopathy who had malignant etiology, 9.8% (n = 4) had necrotic lymph nodes while 90.2% (n = 37) did not.

- Of the 56 patients with lymphadenopathy who had benign etiology, 30.4% (n = 17) patients had necrotic lymph nodes, while 69.6% (n = 39) did not.

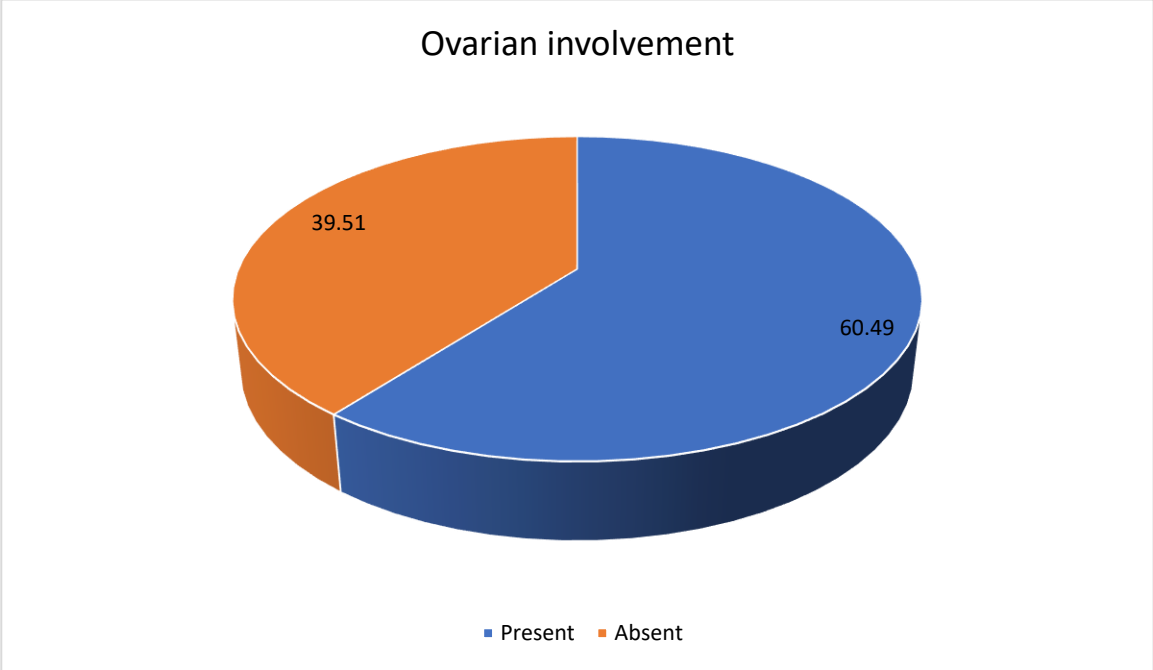


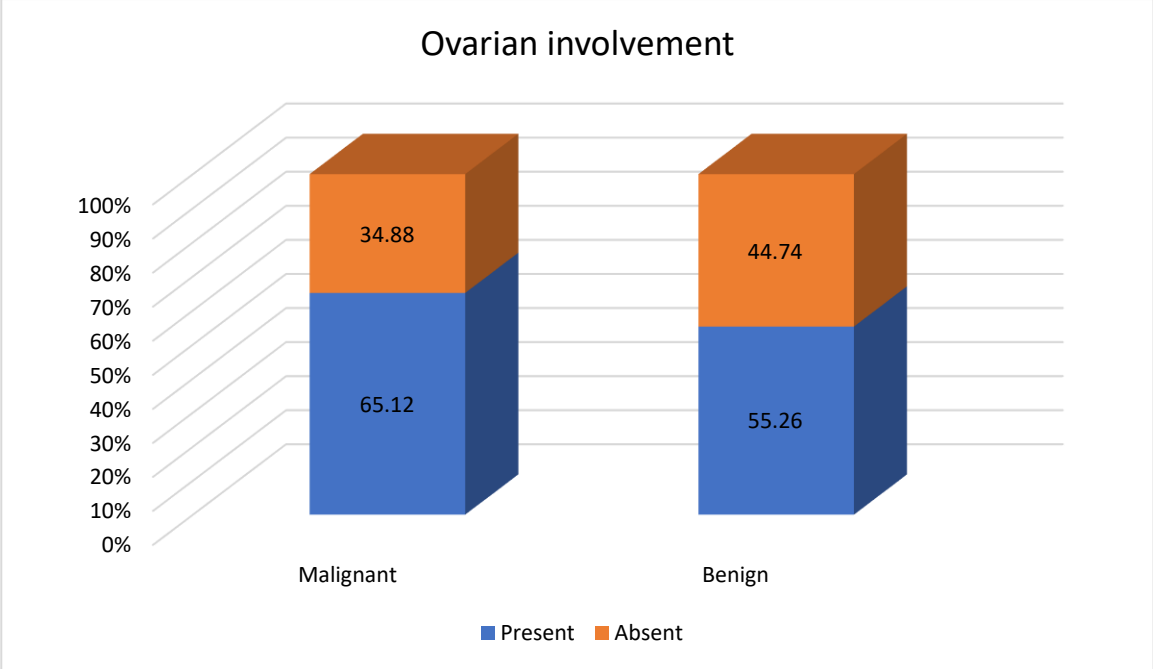
Necrotic lymph nodes	Benign	Malignant	OR (95% CI)	P- Value
Present	17 (30.36)	4 (9.76)	04.03(1.2,13.1)	0.020
Absent	39 (69.64)	37 (90.24)		

- The presence of necrotic lymph nodes had a statistically significant (p = 0.020) positive association with benign etiology.

i) Ovarian involvement

- Was seen in 60.5% (n = 49) of the 81 patients, while 39.5% (n = 32) did not have any ovarian involvement.
- Among the 43 patients with malignant etiology, 65.1% (n = 28) had ovarian involvement while 34.9 (n = 15) had no ovarian involvement
- Among the 38 patients with benign etiology, 55.3% (n = 21) had ovarian involvement, while 44.7 (n = 17) had none.





Ovarian involvement	Malignant	Benign	OR (95% CI)	P- Value
Present	28 (65.12)	21 (55.26)	1.51 (0.61, 3.70)	0.365
Absent	15 (34.88)	17 (44.74)		

The presence of ovarian involvement did not contribute in differentiating malignant from benign etiology.

j) Bowel obstruction

- Of the 72 patients with benign etiology, 2.8% (n = 2) had bowel obstruction, while 97.2% (n = 70) did not.
- Of the 64 patients with malignant etiology, 4.7% (n = 3) had bowel obstruction, while 95.3% (n = 61) did not.

Bowel obstruction	Malignant	Benign	OR (95% CI)	P- Value
Present	3 (4.69)	2 (2.78)	1.72 (0.27, 10.64)	0.554
Absent	61 (95.31)	70 97.22)		

The presence of bowel obstruction did not contribute in differentiating malignant from benign etiology.

k) Terminal ileum or cecal thickening

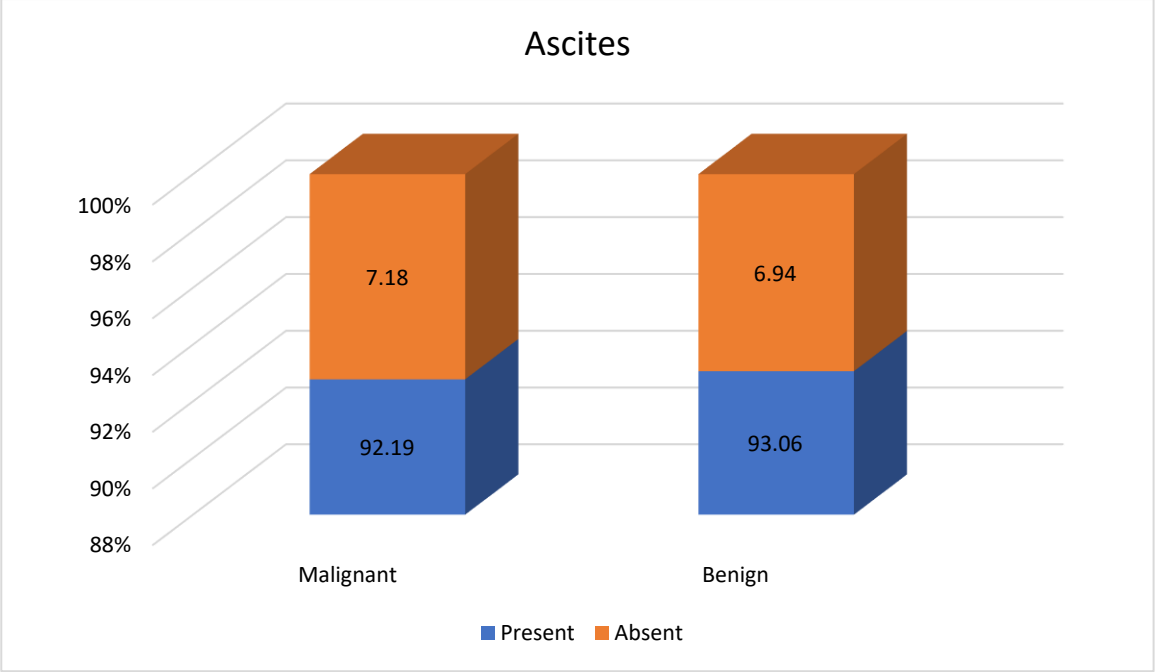
- Was seen in 7.35% (n = 10) of the total 136 patients
- Among the 64 patients with malignant etiology, 9.4% (n = 6) had terminal ileum / cecal thickening while 90.6% (n = 58) had none.
- Of the 72 patients with benign etiology, 5.6% (n = 4) had terminal ileum / cecal thickening while 94.4% (n = 68) did not.

Terminal ileum or cecal thickening	Malignant	Benign	OR (95% CI)	P- Value
Present	6 (9.38)	4 (5.56)	1.75 (0.47, 6.53)	0.394
Absent	58 (90.63)	68 (94.44)		

The presence of thickening of terminal ileum/cecum did not contribute in differentiating malignant from benign etiology.

l) Ascites

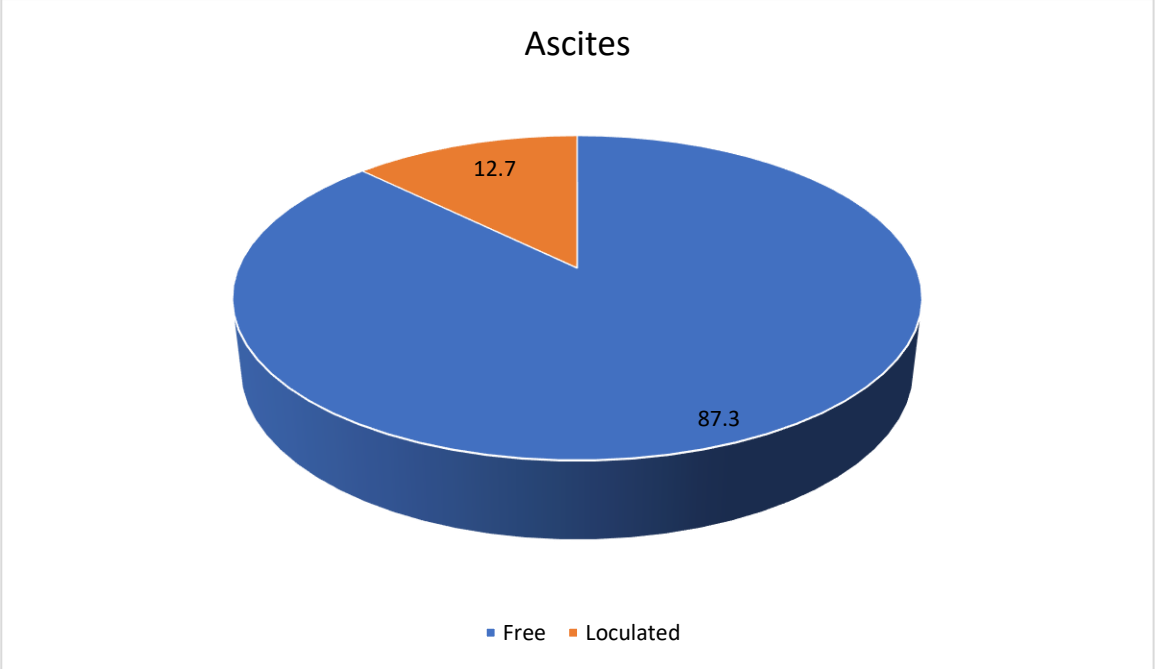
- Was seen in 92.65% (n = 126) patients, while 7.35% (n = 10) had no ascites.
- Of the 64 patients with malignant etiology, 92.2% (n = 59) had ascites while 7.8% (n = 5) did not.
- Of the 72 patients with benign etiology, 93.1% (n = 67) had ascites while 6.9% (n = 5) did not.

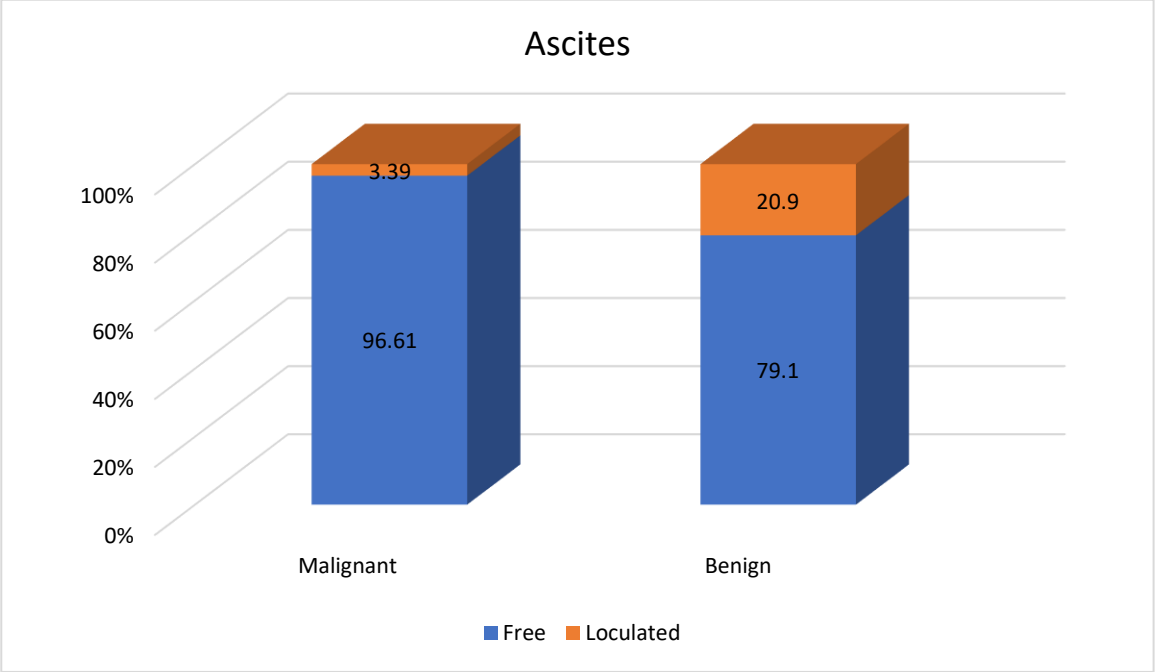


Ascites	Malignant	Benign	OR (95% CI)	P- Value
Present	59 (92.19)	67 (93.06)	0.88 (0.24, 3.19)	0.846
Absent	5 (7.81)	4 (6.94)		

The presence of ascites did not contribute in differentiating malignant from benign etiology.

- Ascites was loculated in 12.7% (n = 16) of the 126 patients and free in 87.3% (n = 110) of the patients.
  - Among the 59 patients with malignant etiology, 96.6% (n = 57) had free ascites while 3.4% (n = 2) had loculated ascites
  - Among the 67 patients with benign etiology, 79.1% (n = 53) had free ascites while 20.9% (n = 14) had loculated ascites.

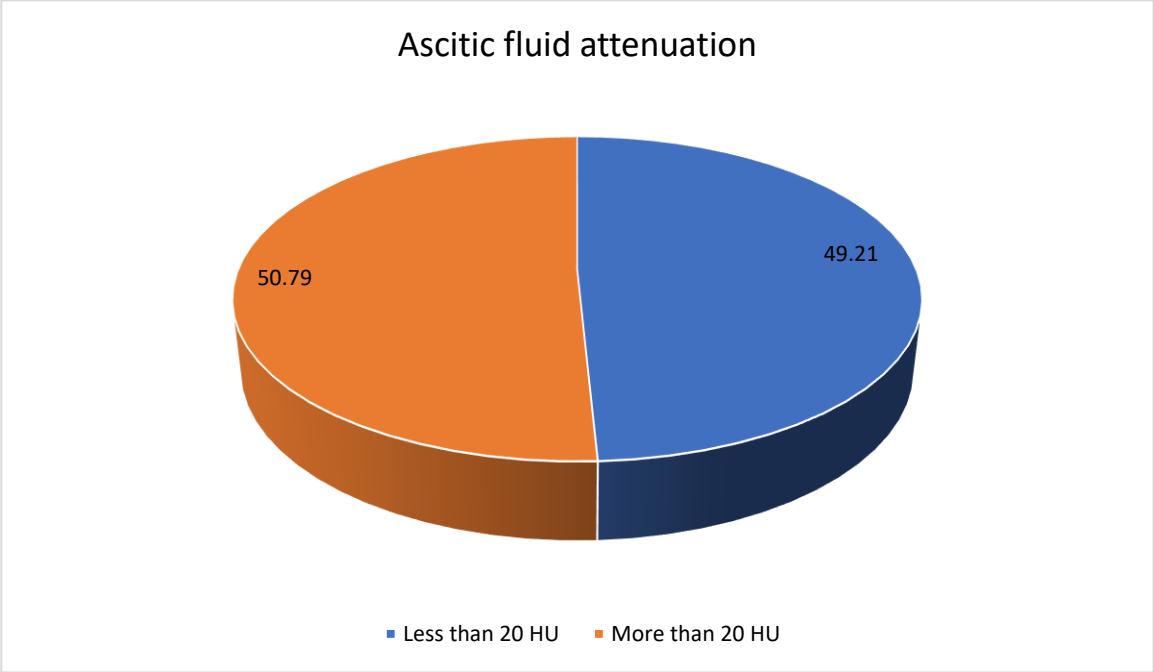


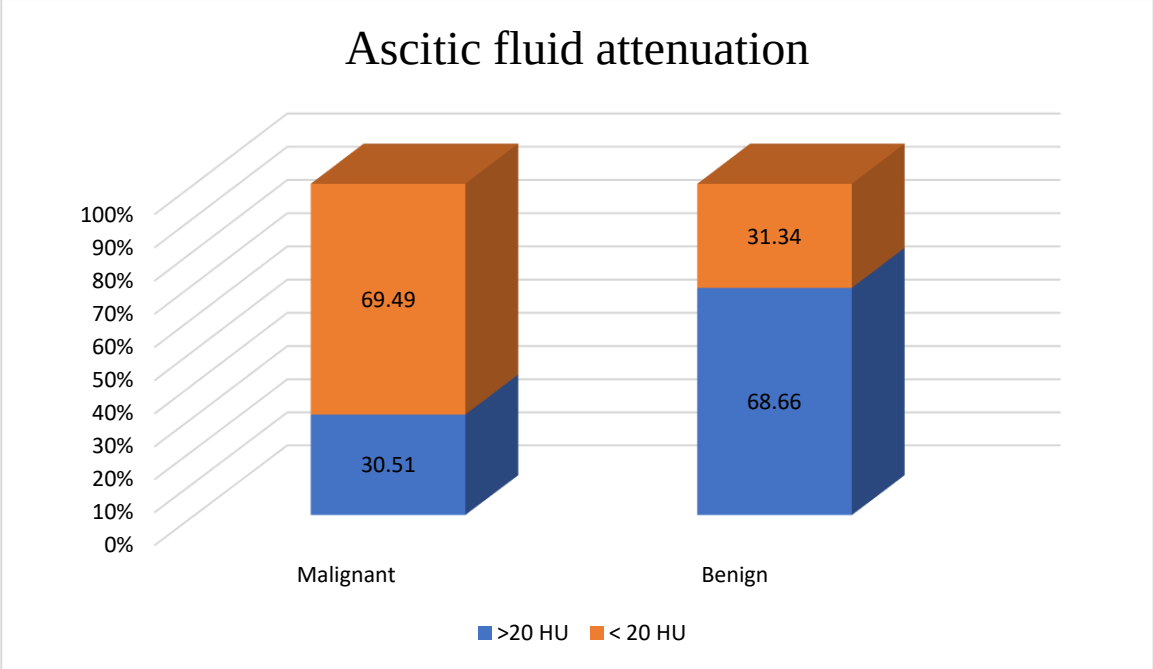


Type of ascites	Malignant	Benign	OR (95% CI)	P- Value
Free	57 (96.61)	53 (79.1)	7.52 (1.63, 34.69)	0.003
Loculated	2 (3.39)	14 (20.9)		

The presence of free ascites had a statistically significant (p = 0.003) positive association with malignant etiology.

- Attenuation of the ascitic fluid was >20 HU in 50.8% (n = 64) while 49.2% (n = 62) of the patients had HU <20.
  - Of the 59 patients with malignant etiology, ascitic fluid attenuation was >20 HU in 30.5% (n = 18) patients while 69.5% (n = 41) had < 20 HU.
  - Among the 67 patients with benign etiology, 68.7% (n = 46) had > 20 HU while 31.3% (n = 21) patients had ascitic fluid attenuation < 20 HU.



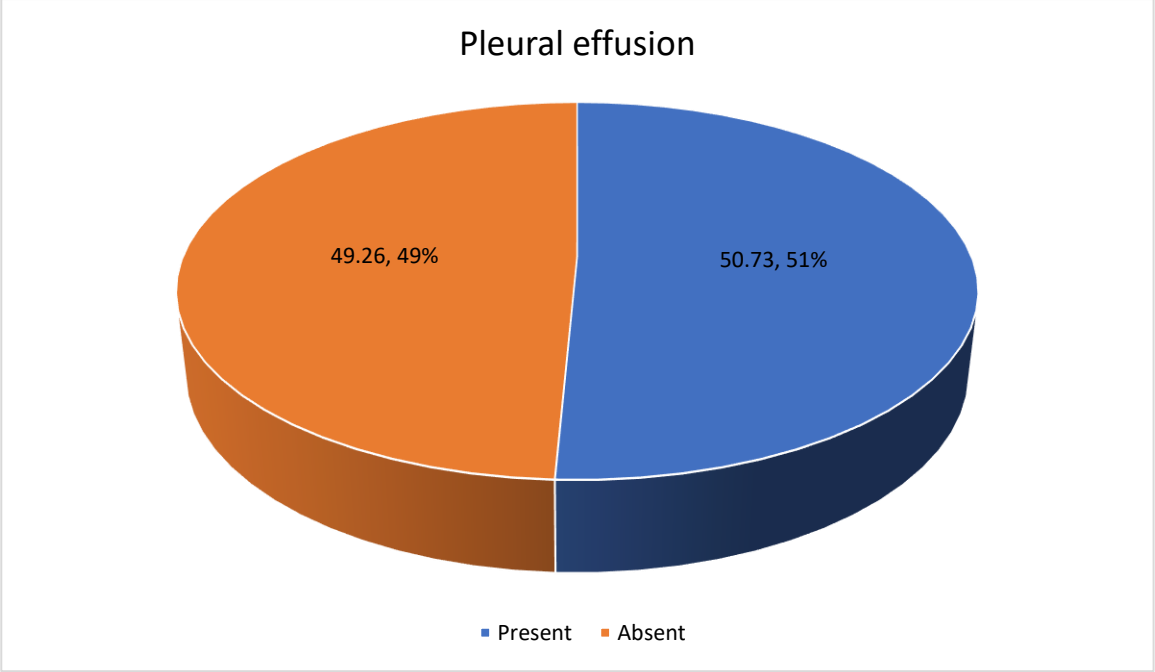


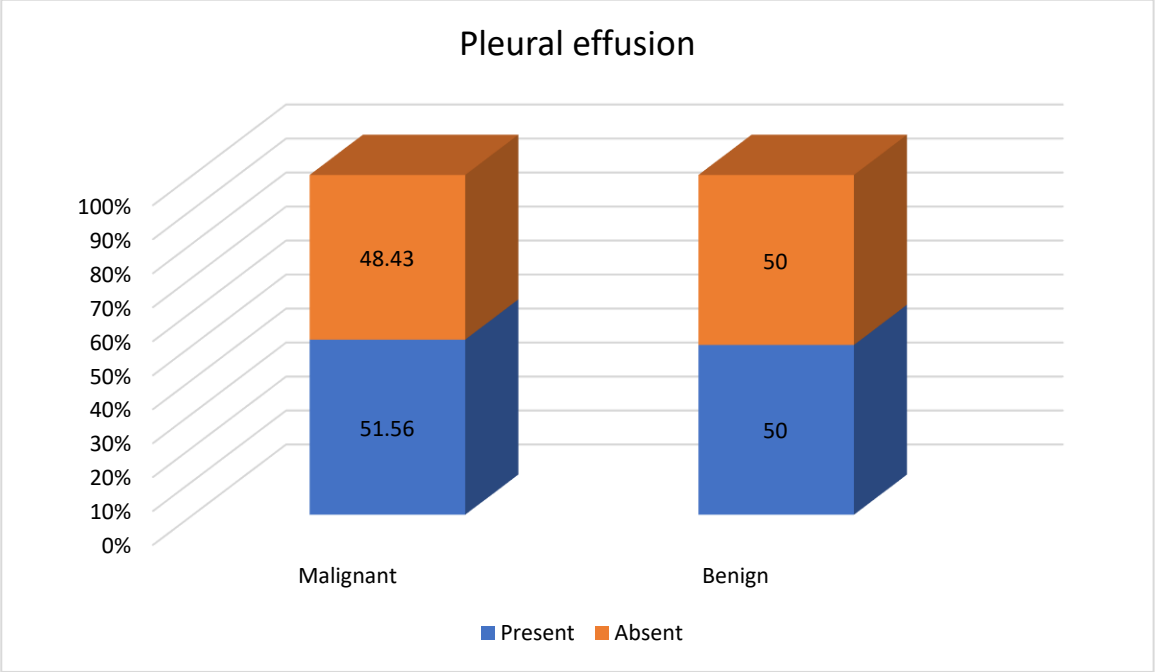
Attenuation	Benign	Malignant	OR (95% CI)	P- Value
>20 HU	46 (68.66)	18 (30.51)	4.98 (2.33, 10.64)	0.000
< 20 HU	21 (31.34)	41 (69.49)		

- The presence of ascitic fluid with attenuation >20 HU had a statistically significant (p = 0.000) positive association with benign etiology.

m) Pleural effusion

- Was seen in 50.7% (n = 69) of 136 patients, while 49.3% (n = 67) of the patients had no pleural effusion.
- Among the 64 patients with malignant etiology, 51.6% (n = 33) patients had pleural effusion while 48.4% (n = 31) patients did not.
- Among the 72 patients with benign etiology, 50% (n = 36) patients had pleural effusion and an equal 50% (n = 36) did not.

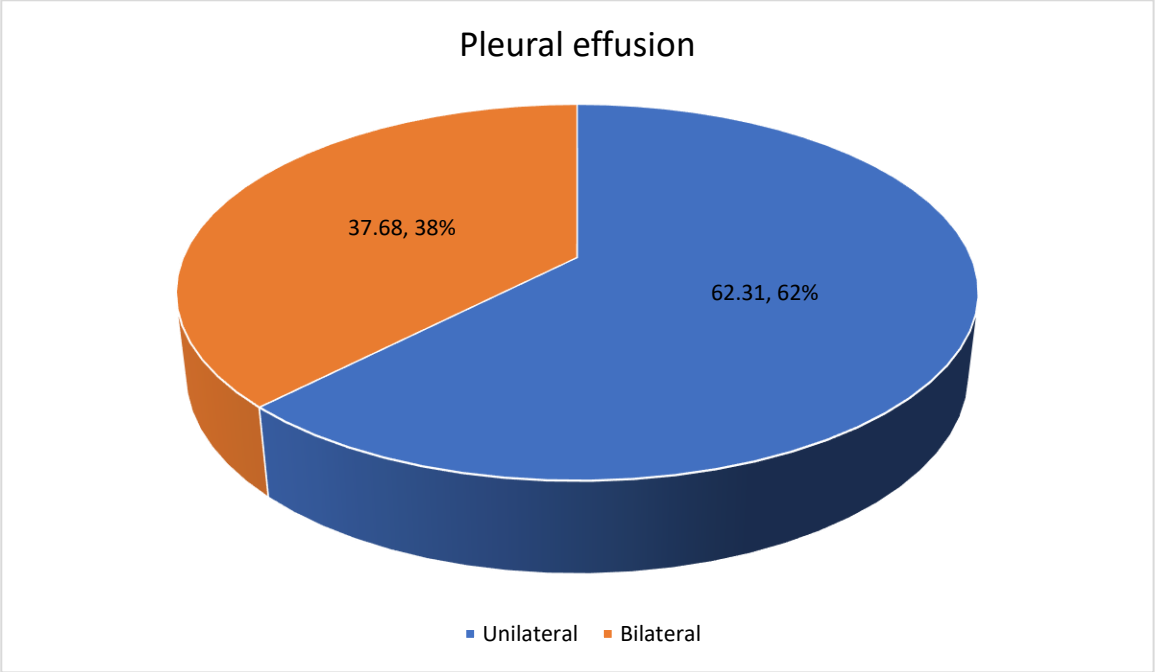


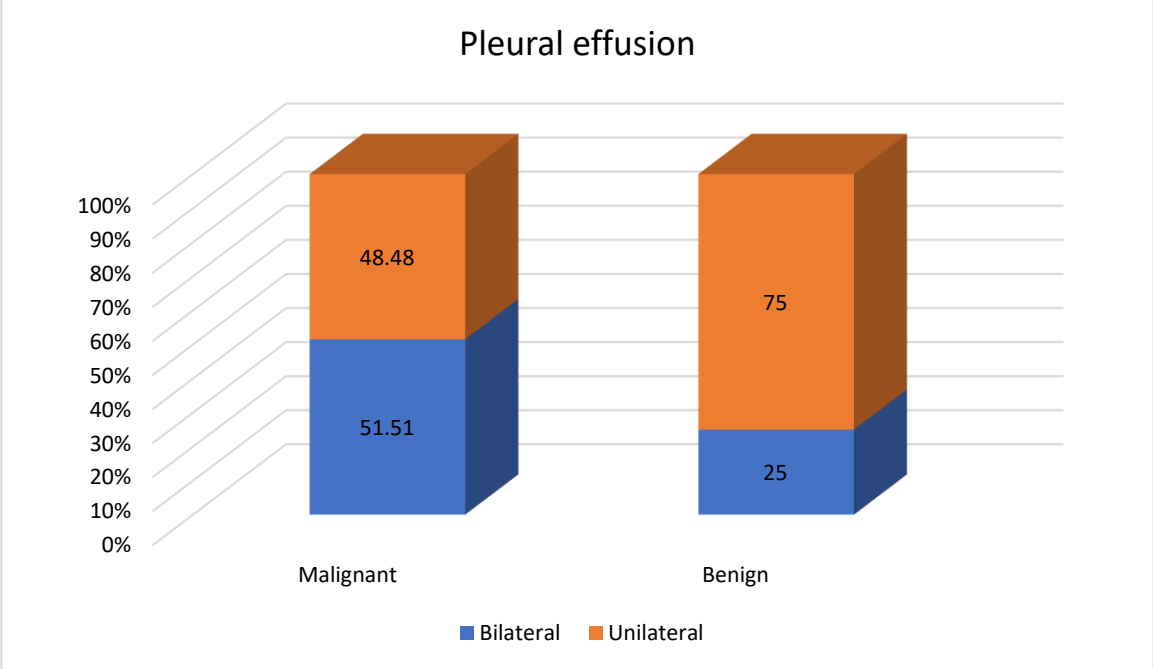


Pleural effusion	Malignant	Benign	OR (95% CI)	P- Value
Present	33 (51.56)	36 (50)	1.06(0.54,2.08)	0.855
Absent	31 (48.43)	36 (50)		

The presence of pleural effusion did not contribute in differentiating malignant from benign etiology.

- Pleural effusion was bilateral in 37.68% (n = 26) of the patients and unilateral in 62.31% (n = 43) patients.
  - Among the 33 patients with malignant etiology, 51.5% (n = 17) had bilateral pleural effusion, while 48.5% (n = 16) had unilateral pleural effusion
  - Among the 36 patients with benign etiology, 25% (n = 9) patients had bilateral pleural effusion while 75% (n = 27) had unilateral pleural effusion.





Type of pleural effusion	Malignant	Benign	OR (95% CI)	P- Value
Bilateral	17 (51.51)	9 (25)	3.18(1.15,8.81)	0.025
Unilateral	16 (48.48)	27 (75)		

- The presence of bilateral pleural effusion had a statistically positive (p = 0.025) association with malignant etiology.

In summary**,** the following findings were most useful in CT differentiation of benign and malignant etiologies of diffuse peritoneal diseases:

Features	**Benign** (n=72)	**Malignant** (n=64)	**p value**
Age (years)	34.9 ± 14.1	53.75 ± 12.6	<0.001
Size of peritoneal nodules (>10mm)	4 (25%)	12 (60%)	0.035
Visceral scalloping	5 (6.9%)	17 (26.6%)	0.001
Omental thickness (mm)	20.69 ± 6.96	25.28 ± 10.09	0.004
Omental mass / caking	12 (16.67%)	34 (53.13%)	<0.001
Mesenteric thickening / stranding	66 (91.67%)	50 (78.13%)	0.026
Size of mesenteric nodules (>10 mm)	1 (12.5%)	4 (80%)	0.014
Serosal involvement	23 (31.94%)	36 (56.25%)	0.004
Splenomegaly	14 (19.4%)	1(1.6%)	<0.001
Mesenteric adenopathy	30 (53.6%)	7 (17.07%)	<0.001
Necrotic lymph nodes	17 (30.36%)	4 (9.8%)	0.020
Free ascites	53 (79.1)	57 (96.6%)	0.003
Ascitic fluid attenuation >20 HU	46 (68.66%)	18 (30.51%)	<0.001
Bilateral pleural effusion	9 (25%)	17 (51.51%)	0.025

Interobserver analysis assessment and diagnostic accuracy:

- There was substantial interobserver agreement for overall CT prediction of benign or malignant etiology of diffuse peritoneal disease with a Kappa of 0.713 and a standard error of 0.06. (Landis and Koch, 1977)(31)
- The following table shows the diagnostic performance of CT prediction of etiology of diffuse peritoneal disease using the above described CT findings which were found to be statistically significant:

	Observer 1	Observer 2
Sensitivity (95%CI)	**79.2 %** (65.9 – 89.2%)	**74.6%** (61.6-85%)
Specificity (95%CI)	**79.4%** (67.9 – 88.3%)	**97.1%** (89.9 – 99.6%)
Positive predictive value (95%CI)	**75%** (61.6 – 85.6%)	**95.7% (**85.2 – 99.5%)
Negative predictive value (95%CI)	**83.1%** (71.7 – 91.2%)	**81.7%** (71.6 – 89.4 %)
Accuracy (95%CI)	**79.3 %** (71.0 – 86.2%)	**86.7% (**79.6- 92.1%)

Specific analysis of TB vs peritoneal carcinomatosis:

Features	**TB (n=58)**	**Peritoneal carcinomatosis (n=58)**	**p value**
Age (years)	34.6 ± 13.6	54.1 ± 12.7	<0.001
Visceral scalloping	4 (6.9%)	17 (29.3%)	0.003
Omental thickness (mm)	21.5 ± 7.2	25.4 ± 10.4	0.025
Omental mass / caking	11 (18.9%)	31 (53.4%)	<0.001
Mesenteric thickening / stranding	54 (93.1%)	44 (75.8%)	0.016
Size of mesenteric nodules (>10 mm)	1 (14.3%)	4 (80%)	0.041
Serosal involvement	22 (37.9%)	33 (56.9%)	0.042
Splenomegaly	10 (17.24%)	1 (1.7%)	0.020
Mesenteric adenopathy	27 (57.4%)	6 (15.3%)	<0.001
Necrotic lymph nodes	14 (29.8%)	4 (10.2%)	0.033
Free ascites	43 (81.1%)	52 (96.3%)	0.025
Ascitic fluid attenuation >20 HU	36 (67.9%)	16 (29.6%)	<0.001
Bilateral pleural effusion	5 (17.2%)	14 (48.3%)	0.015

The above findings were almost matching with the benign vs malignant analysis as the majority of these 2 categories included TB and peritoneal carcinomatosis. The presence

of peritoneal nodules with size > 10 mm did not contribute to differentiating between TB and peritoneal carcinomatosis.

Multivariate analysis:

Variables	Odds Ratio (95% CI)	Std. Error	P value
Peritoneal nodules with sizes > 10 mm	5.06 (0.09 – 284)	10.40	0.43
Visceral scalloping	7.03 (0.22 - 221)	12.38	0.26
Mesenteric nodules	1.26 (0.02 - 69.5)	2.58	0.91
Serosal involvement	5.88 (0.21 – 166)	10.02	0.29
Mesenteric adenopathy	0.03 (0.001 - 0.8)	0.05	0.04
Necrotic lymph nodes	0.48 (0.01 – 15.2)	0.84	0.68
Attenuation of ascitic fluid >20 HU	2.7 (10.11 – 67.5)	4.45	0.54

The mutually adjusted regression reported an R^2 of 51.82% and the only variable significant was mesenteric adenopathy and which favoured benign etiology.

DISCUSSION

Differentiating the varying etiologies of peritoneal disease can be an arduous task even with the help of imaging guidance. Only few studies have been conducted to study the various findings on CT which could answer the million-dollar question, “Is it benign or malignant?”. Our study to assess the role of CT in evaluating diffuse peritoneal disease included a total of 136 patients. The most common benign etiology in our study was tuberculosis (58 patients), the rest being amyloidosis and few nonspecific inflammation (13 patients). The most common malignant etiology was metastatic adenocarcinoma (51 patients), the rest being malignant mesothelioma (3 patients), pseudomyxoma peritonei (6 patients), 2 patients with primary peritoneal carcinoma, 1 lymphoma and 1 with malignant GIST. Since there were very small numbers of few diagnostic subgroups, we primarily assessed these patients on the basis of whether their final diagnosis was of malignant or benign etiology on histopathological evaluation.

The mean age of our study population was 43.77 and we found a statistically significant ($p = <0.001$) association of older age (mean age of 53.75 years) with malignant etiology. This is similar to the study by A.C. O’Neill et al. in which peritoneal carcinomatosis was seen in an older cohort with a mean age of 67.4 years (25).

Our study, which had 81 female patients and 55 males, did not find any gender predilection for benign or malignant etiology.

The CT findings were assessed under the following headings:

Peritoneum:

The mean thickness of peritoneum in our study was 6.78 mm. Since there were no defined criteria for peritoneal thickening, we considered all patients with peritoneal

thickness of ≥ 2 mm as thickened peritoneum which constituted 95.5 % of our study patients. A slightly lower percentage peritoneal thickening, 72% was seen in the study by A.C. O'Neill et al. In another study, by Charoensak et al, the corresponding figure was even lower (50%) (27). We did not find any significant positive association of peritoneal thickness with malignant etiology. Irregular type of thickening which was seen in 69.23% of our patients did not have any significant positive association with malignant etiology either. This finding is in contrast to the study by Charoensak et al. in which they found a statistically significant association of irregular peritoneal thickening with peritoneal carcinomatosis.

Peritoneal nodules were seen in 26.47 % of our patients, in contrast to the study by A.C. O'Neill et al. in which the incidence of peritoneal nodules was as high as 75%. There was no statistically significant positive association of the peritoneal nodules with malignant etiology. This finding is in sharp contrast to the study by Charoensak et al in which they found a statistically significant association of peritoneal nodules with malignant etiology.

The presence of peritoneal nodules with sizes more than 10 mm, had a positive association with malignant etiology and was found to be statistically significant (p= 0.035). This finding was in contrast to the study by Charoensak et al. in which the size of peritoneal nodules was not useful in differentiating benign from malignant etiology. The number and density of peritoneal nodules did not show any association with malignant etiology. Peritoneal cysts were seen in only one patient and who had a malignant etiology.

Scalloping of the visceral organs, primarily the liver and the spleen, was seen in 16.18% of our study patients and had a statistically significant (p = 0.001) positive association with malignant etiology. This is in contrast to a previous study by Sharma et al. which did not find any conclusive difference between TB or peritoneal carcinomatosis in relation to the presence of visceral scalloping (32).

Omentum:

The study by Charoensak et al, comparing TB with peritoneal carcinomatosis did not find any significant difference in omental abnormalities. In our study, omentum was thickened in all 136 (100%) patients with a mean thickness of 22.85 mm. This finding could be owing to the fact that our study population comprised of all patients who underwent omental biopsies, and thereby all of them invariably had omental thickening. There was a statistically significant positive association of omental thickness with malignant etiology with a mean thickness of 25.28mm. This finding is very similar to the study by Ha et al. in which omental thickening was found to be more associated with peritoneal carcinomatosis than tuberculous peritonitis, with a mean thickness of 26 mm (26). Omental stranding did not show any significant association with benign or malignant etiology.

Omental mass/ caking, which was considered when the normal omental fat was found replaced by fibrosis /tumor, was seen in 33.82% of our patients and had a significant positive association with malignant etiology. This was very similar to the study by A.C. O'Neill et al, in which the incidence was 32% and by Charoensak et al. in which the incidence was 31.6%.

Omental nodules, seen in 35.29% of our patients did not have a significant positive association with malignant etiology, similar to the study by Charoensak et al, where the incidence was 31.6%. The size of the omental nodules was not useful to differentiate benign from malignant etiology, much in contrast to peritoneal nodules which had a positive size association with malignant etiology.

There was no association of the number or the density or the presence of calcification within nodules with benign or malignant etiology.

Mesentery:

Thickening or stranding of mesentery which was seen in 85.29% of our patients showed a statistically significant ($p = 0.026$) positive association with benign etiology. This finding was similar to the study by Charoensak et al in which the incidence was 88.9% and a study by Ha et al in which the incidence was 98%. Both these studies showed a high association of mesenteric abnormalities with TB, found to be statistically significant.

Contrastingly however, in a study by Shim et al., although mesenteric thickening was seen in 72.2% of patients with tuberculous peritonitis, this finding was not statistically significant (5).

The presence or the number of mesenteric nodules did not show any significant association with malignant etiology.

The incidence of mesenteric nodules with sizes >10 mm was 38.4% in our study, similar to the study by Charoensak et al. which had 33.3 % and Ha et al in which the incidence of mesenteric nodules with sizes > 5 mm was 24.4%. However, in contrast to these

studies, we found that mesenteric nodules with sizes >10mm had a high association with malignant etiology which was statistically significant (p = 0.014).

Mesenteric masses were seen in only 3 patients, all of which were of malignant etiology and included metastatic adenocarcinoma, lymphoma and malignant mesothelioma.

Serosal involvement:

The involvement of serosa, in the form of thickening or presence of implants was seen in 43.38% of our patients and showed a statistically significant (p = 0.004) association with malignant etiology. This is similar to the incidence in the study by A.C. O'Neill et al, where an incidence of 37% was found among patients with malignant etiology (25).

Hepatomegaly and focal liver lesions:

There was no significant association of hepatomegaly with malignant etiology.

Although not statistically significant, the incidence was higher in benign etiology. This finding could likely be attributed to hepatomegaly being more associated with TB. The presence of focal liver lesions did not show any association with either benign or malignant etiology.

Splenic involvement:

Splenomegaly, seen in 11.03% of our patients had a statistically significant positive association with benign etiology. This could be attributed to higher prevalence of splenomegaly among those with TB. This corroborates with the study by Ha et al where splenomegaly was seen in 92% of patients with tuberculous peritonitis compared to 50% in peritoneal carcinomatosis.

Focal lesions in the spleen however in contrast had no significant association with benign or malignant etiology in our study.

Lymphadenopathy:

Lymph nodes of sizes greater than 10 mm in short axis dimension were considered as significant adenopathy with the exception of lesser omental nodes for which 6mm was taken as upper limit of normal and similarly, 15 mm for para-iliac lymph nodes. We did not find any significant association of intraabdominal lymphadenopathy with malignant or benign etiology. This is in contrast to the study by Charoensak et al where they found that lymph nodes of sizes <10 mm were more frequently encountered in TB while those with sizes >10 mm were more common in peritoneal carcinomatosis.

Mesenteric adenopathy, however, showed a statistically significant association with benign etiology while the rest of the individual lymph nodal stations did not show any association with either benign or malignant etiology.

Necrotic lymph nodes, seen in 21.56% of our study patients showed a statistically significant positive association with benign etiology. This could be attributed to their higher prevalence in cases of TB which characteristically show necrotic nodes.

Ovarian involvement:

Presence of abnormal enhancement or enlargement of ovaries was considered as ovarian involvement. This was seen in 60.49% of the female patients. These had a positive association with malignant etiology, although not statistically significant.

Bowel involvement:

Involvement of bowel in the form of obstruction or thickening of terminal ileum or the cecum although had a higher incidence with malignant etiology, however, this was not statistically significant. This finding however is in contrast to the fact that thickening of terminal ileum /cecum is characteristically seen in cases of TB.

Ascites:

Ascites, seen in 92.65% of our patients did not have any positive association with malignant etiology in itself. Free ascites without loculations had a statistically significant (p= 0.003) positive association with malignant etiology. This finding may be explained by the fact that loculated ascites is commonly associated with infective/inflammatory conditions. This is similar to the finding by Charoensak et al, where in addition they also found that loculated ascites was more frequently encountered with TB peritonitis than with peritoneal carcinomatosis.

The attenuation of ascitic fluid more than 20HU has been proposed to be related to the exudative nature of the fluid in cases of infections (33). Our study corroborates this finding with a statistically significant association of ascitic fluid attenuation of >20 HU with benign etiology primarily including infective and inflammatory causes.

Pleural effusion:

There was positive association of pleural effusion with malignant etiology although not statistically significant. Bilateral pleural effusion was seen to have a statistically significant positive association with malignant etiology.

TB vs Peritoneal carcinomatosis

With the exception of size of peritoneal nodules, similar distribution of all the variables described above were also seen when differentiating between TB and peritoneal carcinomatosis. The presence of large peritoneal nodules >10 mm did not significantly contribute to differentiating TB from carcinomatosis.

Multivariate analysis:

Mesenteric adenopathy was the only variable which was significant, and favoured a benign etiology.

Interobserver analysis:

We found good sensitivity and specificity of CT for differentiating between benign and malignant etiology of peritoneal disease with an accuracy of 79.3 % for observer 1 and 86.7% for observer 2. A higher positive predictive value (95.7%) was noted for observer 2, while for observer 1 the negative predictive value was higher (83.1%). There was also substantial interobserver agreement for overall CT prediction of benign or malignant etiology of diffuse peritoneal disease.

CONCLUSION and LIMITATIONS

CONCLUSION

Contrast enhanced CT was shown to have good sensitivity and specificity for differentiating benign and malignant etiologies of diffuse peritoneal disease.

Higher age, increasing omental thickness, omental caking, larger mesenteric/peritoneal nodules, visceral scalloping, free ascites, serosal involvement and bilaterality of pleural effusion were the findings found to be significantly associated with malignant etiology.

Findings such as mesenteric thickening/stranding, mesenteric adenopathy, necrotic lymph nodes, splenomegaly and higher attenuation (>20HU) of ascitic fluid were found to be significantly associated with benign etiology.

With the exception of size of peritoneal nodules, the variables described above also held true for differentiating between TB and peritoneal carcinomatosis.

Overall, we can conclude that CT has a high diagnostic accuracy for assessment of etiology of diffuse peritoneal disease.

LIMITATIONS

Our study had a few limitations. Firstly, it was a retrospective study. The clinical history and demographic features which were not assessed so as to prevent bias, also deprived us of valuable information which could point towards the final diagnosis in addition to the CT findings. The ability to pick up important CT findings depends to a large extent on the expertise of reading radiologist.

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APPENDIX – 2 CLINICAL RESEARCH FORM (PROFORMA)

S. No: **Age:**

Hospital ID:

Sex:

Male		Female	

CT features:

Findings				Yes	No
Peritoneum	Thickening ----mm		Smooth		
			Irregular		
	Nodule	Size of the largest	<10 mm		
			>10 mm		
		Number	<5		
			>5		
		Density	Predominantly Solid		
			Predominantly Cystic		
			Mixed		
		Calcification	Fine		
			Coarse		
	Scalloping				
	Cysts				
Omentum	Thickening ….mm				
	Mass / Caking				
	Stranding				
	Nodules	Size of the largest	<10 mm		
			>10 mm		

		Number	<5		
			>5		
		Density	Predominantly Solid		
			Predominantly Cystic		
			Mixed		
		Calcification	Fine		
			Coarse		
Mesentery	Thickening / Stranding				
	Mass				
	Nodules	Size of the largest	<10 mm		
			>10 mm		
		Number	<5		
			>5		
		Density	Predominantly Solid		
			Predominantly Cystic		
			Mixed		
		Calcification	Fine		
			Coarse		
Serosal implants / involvement					
Liver	Enlarged				
	Focal lesions				
	IHBRD				
	Fissural involvement				
	Scalloping				
Spleen	Enlarged				
	Focal lesions				
Lymphadenopathy	Station	Mediastinal			

		Diaphragmatic		
		Lesser Omental		
		Greater Omental		
		Mesenteric		
		Para-aortic		
		Para-iliac		
	Necrosis			
Ovarian masses / involvement	NA			
Bowel obstruction				
Terminal ileum or cecal thickening				
Ascites	Free			
	Loculated			
	Attenuation	< 20 HU		
		> 20 HU		
Pleural effusion	UL	BL		
Any other significant finding				

Radiological diagnosis: (Observer 1)

Radiological diagnosis 2: (Observer 2)

Histopathology diagnosis (Omental biopsy):

Radiological diagnosis:

1. TB
2. Carcinomatosis
3. Lymphomatosis
4. Equivocal findings
5. Primary peritoneal malignancy
6. Pseudomyxoma peritonei
7. Others

Histopathological diagnosis:

1. Necrotizing / caseating granulomatous inflammation, s/o TB
2. Non-specific chronic inflammation
3. Metastatic adenocarcinoma
4. Lymphoma
5. Pseudomyxoma peritonei
6. Malignant mesothelioma
7. Primary peritoneal carcinoma
8. Amyloidosis
9. Metastatic GIST

APPENDIX – 3 DATA SHEETS

slno	AGE	hospno	sex	perthick	pthickyes	thicksi	perinodule	pnodulesiz	pnodulen	pnodden	pnodcal	periscall	pericysts	omenthick	omenthickyes	ommass	omstrand	omennodule	omnodsize	omnodno	omnodden	omnodcal	mesthick	mesmass	mesnodule
1	22	533608F	2	1	7.2	2	1	2	1	1		2	2	1	12	1	1	1	1	2	1		1	2	2
2	31	930190G	2	1	3	1	2					2	2	1	19	2	1	2					1	2	2
3	22	566039G	2	2	2		2					2	2	1	23.2	2	1	2					1	2	2
4	33	906344G	2	1	2.5	1	2					2	2	1	12.6	2	1	2					1	2	2
5	43	047636H	1	1	3.5	2	2					2	2	1	18	2	1	2					1	2	2
6	18	058712H	2	1	5.4	2	1	2	2	1		2	2	1	20	1	1	1	2	2	1		2	2	2
7	40	071047H	2	1	13	2	1	2	2	1		1	2	1	15	1	1	1	1	2	1		1	2	2
8	58	794671F	2	1	5.5	1	2					2	2	1	26.6	1	1	2					1	2	1
9	32	932212G	2	1	9	1	2					2	2	1	33	1	1	2					1	2	2
10	29	986611G	1	1	3	2	1	2	2	1		2	2	1	19	2	1	1	1	1	1		1	2	1
11	33	979989G	1	1	5	1	2					2	2	1	15	2	1	2					1	2	2
12	18	778433D	1	1	5	1	2					2	2	1	26.7	1	1	1	1	2	1		1	2	1
13	25	961084G	1	1	3	1	2					2	2	1	10	2	1	2					1	2	2
14	56	002712H	1	1	6	2	1	1	2	1		2	2	1	22.4	2	1	1	1	2	1		1	2	1
15	46	578184G	1	1	3	1	2					2	2	1	27.6	2	1	2					1	2	2
16	32	024453H	2	1	5	2	1	2	2	1		2	2	1	15	2	1	1	1	2	1		1	2	1

17	20	693181G	2	1	3	2	2					2	2	1	16	2	1	2					1	2	2
18	23	703049G	1	1	3	1	2					2	2	1	29	2	1	2					1	2	2
19	56	647645G	2	1	6	1	2					2	2	1	32.6	1	1	2					1	2	2
20	46	526433G	2	1	8.5	2	2					2	2	1	25	1	1	2					2	2	2
21	23	937876G	1	1	9	2	1	1	1	1		2	2	1	20	1	1	1	2	2	1		1	2	2
22	56	233396C	2	1	6.5	2	1	1	2	1		2	2	1	25.6	1	1	2					1	2	1
23	61	940029G	2	1	4	2	2					1	2	1	16	2	2	2					2	2	2
24	42	916163G	2	1	2	2	2					2	2	1	20	1	1	1	1	2	1		1	2	2
25	75	912187G	2	1	4	2	2					2	2	1	24	2	1	1	1	2	1		1	2	1
26	45	962920G	2	1	2.5	2	2					1	2	1	15	2	1	1	1	2	1		1	2	2
27	61	933538G	2	1	3	1	2					2	2	1	24	2	1	1	1	2	1		1	2	2
28	44	379606F	1	1	5	2	2					2	2	1	4	2	1	2					2	2	2
29	58	934230G	2	1	3	1	2					2	2	1	32	1	1	2					2	2	2
30	28	842745G	1	1	1.5	1	2					2	2	1	17	2	1	2					1	2	2
31	40	991061G	2	1	6	2	2					2	2	1	33	1	1	2					1	1	1
32	58	934616G	2	1	4	2	2					2	2	1	38	2	1	1	1	2	1		1	2	2
33	43	984641G	1	1	23	2	2					2	2	1	25	1	1	2					1	1	2
34	49	041945H	2	1	3.5	1	2					2	2	1	20	2	1	1	1	2	1		1	2	2
35	67	581027G	2	1	2	1	2					2	2	1	34	2	1	1	1	2	1		1	2	2

36	39	441719G	1	1	7	2	2					1	2	1	4	1	1	1	1	2	1		1	2	2
38	28	935802G	1	1	4.5	2	1	1	1	1		2	2	1	20	2	1	1	1	2	1		1	2	2
39	24	982288G	2	1	3	1	2					2	2	1	12	2	1	2					2	2	2
40	65	931326G	1	1	5	2	2					2	2	1	14	2	1	2					2	2	2
41	29	939444G	2	1	51	2	2					2	2	1	17	2	1	1	1	2	1		1	2	1
42	21	382243G	1	1	4.5	2	2					2	2	1	21.3	2	1	2					1	2	2
43	56	994659F	2	1	6.4	2	1	1	1	1		2	2	1	45.8	2	1	1	1	2	1		1	2	2
44	88	376711G	2	1	3.3	2	2					2	2	1	18.8	2	1	1	2	2	1		1	2	2
45	43	738471D	2	1	16	2	1	2	2	1		1	2	1	36.5	1	1	1	2	2	1		1	2	2
46	51	992060F	2	1	3	1	2					2	2	1	13.5	2	1	2					1	2	2
47	46	396393G	1	1	5.6	2	2					2	2	1	32.8	2	1	2					1	2	2
48	49	388428G	2	1	10	2	2					1	2	1	35	2	1	2					1	2	2
49	19	997524F	2	2	1.5		2					2	2	1	12	2	1	1	2	2	1	2	1	2	2
50	54	997727F	1	1	6	1	2					2	2	1	28	1	1	2					1	2	2
51	61	414780G	2	1	5.5	2	1	1	2	1	2	2	2	1	20	1	1	1	1	2	1	2	1	2	2
52	60	410668G	2	1	5.7	2	2					1	2	1	29	1	1	2					1	2	2
53	78	390616G	1	1	5	2	1	1	2	1		1	2	1	38	1	1	1	1	2	1		1	2	2
54	33	635648F	2	1	3	1	2					2	2	1	15	2	1	2					1	2	2
55	45	425468G	2	1	3	2	2					1	2	1	23.8	2	1	1	2	1	1		1	2	2

56	15	991432F	2	1	4.5	2	1	1	2	1		2	2	1	24	1	1	1	2	2	1		1	2	2
57	59	431023G	2	1	4	2	2					2	2	1	20	2	1	1	1	2	3		2	2	2
58	66	500559G	2	1	6	2	1	1	2	1		2	2	1	15.5	2	1	2					1	2	1
59	56	465559G	2	1	5	2	2					2	2	1	24	1	1	1	1	2	1		1	2	2
60	45	457886G	1	1	5	2	2					2	2	1	20	2	1	1	1	2	1		1	2	2
61	40	474045G	1	1	3	1	2					2	2	1	23	2	1	2					1	2	2
62	30	487624G	2	1	46	2	1	2	2	1		1	2	1	15	2	1	2					1	2	2
63	25	483775G	1	1	4.5	2	2					2	2	1	40	2	1	2					1	2	2
64	66	841329D	2	1	3	1	2					2	2	1	21.5	1	1	2					1	2	2
65	64	482872G	1	1	32	2	1	2	2	1		1	2	1	19.7	2	1	2					1	2	2
66	58	494245G	1	1	4	1	1	1	1	1		2	2	1	22.6	2	1	1	1	2	1		1	2	2
67	60	817647G	1	1	4	1	2					2	2	1	24.2	2	1	2					1	2	2
68	45	605634G	2	1	4	2	2					2	2	1	20.4	2	1	1	1	2	1		1	2	2

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